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ABSTRACT

The Science Assessment Program is part of the overall Manitoba assessment program as recommended by the Joint Committee on Evaluation and approved by the Minster of Education and Training. This report contains a description and analysis, along with conclusions and recommendations of the assessment conducted in Science 100, Biology 200, and Physics 300. Surveys of the science teachers teaching these courses are reported. Among the reported results are the following: (1) student results for the subtests for the Science 100 test were satisfactory for the core subjects which included measurement and evaluation, separation of substances, and characteristics of matter. The only negative aspect of the overall results was that the written response component was frequently not attempted. Results on the Biology 200 test indicate students did reasonably well on the multiple choice questions but written response items were unsatisfactory. Physics 300 students were able to do straightforward applications of formula, but had difficulty where transfer of knowledge and interpretation were required. A comparison of chemistry 200/300 results show that scores in calculations declined between 1981 and 1990. A separate "Summary Report" presents a summary of the test results. (PR)

MANITOBA SCIENCE ASSESSMENT 1990

Final Report

Manitoba
Education
and Training

MANITOBA SCIENCE ASSESSMENT 1990

FINAL REPORT

A REPORT OF THE

CURRICULUM SERVICES BRANCH

MANITOBA EDUCATION AND TRAINING

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January, 1993

PREFACE

This report contains a description and analysis, along with conclusions and recommendations of the Assessment conducted in Science 100, Biology 200, and Physics/Physique 300. Since the number of Français and French Immersion students taking Physique 300 was very small, the results of these students were combined with those of English-language Physics 300 students and reported as one group. The results for Français and French Immersion Sciences 100 students are reported in a separate document. Biologie 200 was not assessed at this time.

There are three components to the Science Assessment:

- Science/Sciences 100, Biology 200, and Physics/Physique 300
- Survey of Teachers of Science/Sciences 100, Biology 200, and Physics/Physique 300
- Comparison of student achievement in Chemistry 200 and 300 from 1981 to 1990.

There are a number of other reports on this assessment. There is one Preliminary Report for each group included in the assessment.

Science 100	English-language program
Sciences 100	Français program
Sciences 100	French Immersion program
Biology 200	English-language program
Physics/Physique 300	English-language, Français, and French Immersion programs

There is a further report, the *Science Assessment Program 1990 Summary Report*, which is an abridgment of this *Final Report*. Both the Preliminary and Summary reports are distributed widely to schools, school division offices, and teacher and trustee organizations, as well as to libraries and universities. This *Final Report* will be distributed only to school division offices, teacher and trustee organizations, libraries, and universities. Copies of this report may be obtained from Manitoba Education and Training.

The Technical Advisory Committee of teachers and other educators developed the recommendations in this report. These recommendations are based upon an analysis of the data collected and upon the judgment of the members of the Technical Advisory Committee in the light of their considerable knowledge and experience. Educators are encouraged to review these reports for applicability to their programs.

ACKNOWLEDGEMENTS

This assessment would not have been possible without assistance and cooperation of people too numerous to mention: the students who wrote the tests; teachers who administered the tests; those who assisted us with the pilot testing; and teachers and others who assisted in the review of the objectives. Special mention must be made of a number of groups and individuals:.

- The contractors who gave professional assistance in every phase of the project.
- The Joint Committee on Evaluation which provided guidance throughout the program.
- The Science Technical Advisory Committees which advised on test production and analysis of results (see list of names on page v).
- The teachers who participated in the teacher surveys.
- The divisions and schools that released their teachers to assist in the program.
- The secretaries of Manitoba Education and Training for their excellent work in typing the manuscripts.

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CHAPTER 1

The Background

Purpose:

The Science Assessment Program is part of the overall Manitoba assessment program as recommended by the Joint Committee on Evaluation (JCE) and approved by the Minister of Education and Training. The purposes of the assessment are:

1) To provide benchmark indicators about the level of student achievement in the Province of Manitoba.

2) To obtain data on student achievement that will assist in curriculum and program improvement at the provincial and local levels.

3) To assist school divisions in student and system evaluation.

4) To help teachers improve their evaluation skills.

In the Science/Sciences 100, Biology 200 and Physics/Physique 300, new information was obtained with respect to curriculum achievement. In Chemistry 200 and 300, the results of 1990 were compared to those of 1981. This, too, is part of the ongoing process of comparison testing at Manitoba Education and Training.

The Science Assessment was intended to provide a broad base of accurate and current information on the performance of students in Manitoba. No special preparation was made to write these tests so the results reflect an "everyday" level of performance as opposed to an optimum level. From a curricular standpoint, this provides a measure of the extent to which the provincial curriculum is being learned.

Components:

The 1990 Science Assessment Program was administered in the Spring of 1990 to students in Science/Sciences 100, Biology 200 and Physics/Physique 300. Students were given the test in their language of instruction (English or French). The Chemistry 200 and 300 Comparison testing was administered only in the English language as was done in 1981. Biologie 200 will be assessed in 1992.

All the tests, except Science/Sciences 100, focused on the Core Topics of their respective curriculum. Science/Sciences 100 tested three compulsory Core Topics, four required options and one additional option. It was not feasible to test the many options in the other programs since this would have resulted in huge test booklets, difficulty in administering the tests, and confusion to students completing the tests.

In every instance, the tests comprised multiple choice items and long answer type questions. The limitations of costs prohibit wider use of supply-type items, particularly those designed to test process skills. However, the current proportion of selection-type and supply-type items allows for adequate cross-referencing of students' understanding of concepts.

In addition to the written test, the Science Assessment Program consisted of a Teacher Survey of all the courses assessed except Chemistry 200 and 300. This is considered a valuable component of the assessment program in that it provides authentic information regarding teacher and student interaction with the prescribed curriculum.

In its earlier deliberations, the Technical Advisory Committee considered including a Performance component in each test. However, the limitations of cost discouraged further action in this direction. The merits of a Performance component in the Assessment Program, especially in the sciences, were certainly endorsed.

__Time__:

The assessments were conducted towards the end of May and beginning of June, 1990. It was felt that teachers and students of full-year and second-semester programs would have been concluding their programs by that time. The timing of provincial assessments has always come under question. Some teachers, especially those in semestered schools, claim that assessments conducted in late May or early June greet them well short of completing the prescribed curriculum. But, Manitoba Education and Training wishes to avoid conflicts with locally-administered examinations and out-of-school activities.

CHAPTER 2

Methodology

The procedures used in the Science Assessment Program were similar to those used in other subject areas. Following the approval of the Science Assessment, a Technical Advisory Committee (TAC) was established for each course designated to be assessed in 1990. A contractor was enlisted to assist in the actual development of each test and reporting of results. The TAC members were experienced teachers who represented English Language, French Immersion, and Français schools. These schools reflect a cross-section of large and small schools from rural and urban settings. The contractors were educators with considerable experience and extensive background in the field being tested, and were, indeed, practising teachers. One person from the Assessment Section, Manitoba Education and Training, served as chairperson of the TAC. Manitoba Education and Training Curriculum staff acted as consultants to the TAC.

The major steps involved in the Assessment Program are outlined below.

Step 1: Identification of Objectives

Regional meetings were held with teachers and department heads of each science course being assessed. The course objectives were arranged according to subtests on a grid which facilitated their rating according to importance for testing. The summarized ratings were studied by each TAC and care was taken to ensure that there was a fair testing of objectives on each subtest. For purposes of consistency, the objectives selected for testing in the English language tests and the French language tests in each of Science 100 and Physics 300 were the same. The English language TAC and French language TAC worked jointly on this activity.

The Chemistry 200 and 300 comparison testing replicated those objectives that were assessed in 1981 with adjustments made to match the 1990 curriculum. In fact, the 1990 test turned out to be a one-hour test as opposed to a two-hour test that was administered in 1981.

Step 2: Test Sample

Students identified for the assessment consisted of those in full-year or second-semester programs. For English language programs, random samples of students were identified from class lists provided by public schools in the province. A ten percent sample was selected in Science 100, 20% samples in each of Biology 200 and Physics 300. Due to smaller enrollments in Français and French Immersion programs, all students enrolled in Sciences 100 and Physique 300 were identified for the provincial sample. Biologie 200 was not tested at this time.

In Chemistry 200 and 300 Comparison testing the provincial sample consisted of 28 schools randomly selected for each of Chemistry 200 and 300. This represented approximately 20% of the schools offering Chemistry 200 and 300. This sampling procedure differed from that of 1981 in which approximately 20% of all Chemistry 200 and 300 students in Manitoba's public schools were randomly designated in advance for the provincial sample.

The cluster sampling employed in 1990, as opposed to simple random sampling, proved to be administratively efficient for Manitoba Education and Training in that fewer schools had to be contacted. The overall cost of obtaining a completed assessment was substantially lower for cluster sampling.

Step 3: Test Development

Each TAC established the Table of Specifications and recommended the format for the respective test. It provided guidelines regarding the length of each test, the number of items per subtest, and item format.

The contractors, with the assistance of the TAC, generated the test items according to the Table of Specifications. The test items and the instrument as a whole were reviewed by TAC prior to piloting. Care was taken to ensure appropriateness of vocabulary and readability level, clarity of questions, and the technical quality of the items. Following the pilot, each TAC examined the results obtained and reviewed the respective test instrument and Teacher's Manual making appropriate changes.

In the case of Chemistry 200 and 300, the 1981 tests were reviewed and items that were no longer appropriate to the 1990 curriculum were deleted. The items that were retained were presented exactly as the 1981 editions.

Step 4: Pilot Testing

All the instruments were piloted except for Chemistry 200 and 300. Pilot testing was done in mid-December using first-semester students. Care was taken to include students of varied ability and background, from large and small schools and from urban and rural settings.

Teachers involved in the pilot testing were asked to provide feedback through a questionnaire on various aspects of the test instrument and the Teacher's Manual. Some of the areas in which feedback was obtained were: match between items and objectives, clarity of item presentation, test layout, readability level, length of test, and other problem areas discerned from students' questioning.

Each TAC considered the test data generated from student performance, together with the feedback from teachers, in the instrument review exercise. Test developers incorporated the recommended changes in refining their respective instrument before the TAC conducted its final review.

Step 5: Test Administration

Tests were administered to the students in the provincial sample during the week of May 28 to June 1, 1990. Schools or school divisions that opted to have all their students tested conducted the testing at the same time. Manitoba Education and Training offered a scoring service to these schools or divisions but the actual marking of the open-ended questions for the non-provincial sample was done locally. The local decision to test beyond the provincial sample provided teachers, schools and divisions the opportunity to analyze their own results along with the provincial findings. Tests were requested by teachers, schools or school divisions for 93% of schools offering Science 100, 95% offering Biology 200, and 91% offering Physics 300. The entire population of students enrolled in Sciences 100 and Physique 300 formed the provincial sample.

Special NCS answer sheets were used to record student responses. For the multiple choice items, students recorded their answers directly on the answer sheets. They wrote their answers in the test booklets for the supply-type items. Special coding was necessary for these long answer questions in order for the answers to be recorded on the special answer sheets for machine scoring. Schools or divisions took care of this for the *non-provincial sample*. Manitoba Education and Training looked after the *provincial sample*.

Specific instructions were required to facilitate the preparation of the answer sheets for scanning at Management Information Services, Manitoba Education and Training. Each teacher administering the tests was provided with a Teacher's Manual and Scoring Key. Special coding instructions were included.

Step 6: Interpretation and Reporting of Results

Manitoba Education and Training employs a reporting procedure that includes a Preliminary Report, Final Report and Summary Report. For the Science Assessment Program separate reports were prepared for each of Science 100, Sciences 100 (Immersion), Sciences 100 (Français), Biology 200, and Physics/Physique 300. The Physics/Physique 300 reports were translated into French for circulation to the Français and Immersion schools. A combined English language report was prepared for Chemistry 200 and 300 comparison testing.

The *Preliminary Report* was distributed to schools early in the Fall term of the 1990-1991 school year. It provided results for each subtest and each item. The report sent to schools was accompanied by a copy of the respective test which allowed teachers the opportunity to undertake a meaningful examination of the test data. Mean scores for each item and subtest were provided and these formed the best indicators of performance. There was no overall score for the course tested. Teachers, schools and divisions were warned against using these data to reflect the level of achievement in their own classrooms, schools or divisions. The main purpose of the assessment is to look at individual topics in each Science assessment.

The *Final Report* presents an analysis of the results for each course. It contains the major findings plus the conclusions and recommendations made by the TAC and Contract team. A copy is sent to school division offices, teacher and trustee organizations, libraries, and universities.

The *Summary Report* provides a brief description of the findings and recommendations for each course. It is circulated widely to schools so that teachers can utilize the results in planning their programs and instruction. It serves as a source of information to other educational constituencies about the present status of curriculum strengths and weaknesses.

THE TEACHER SURVEY

In addition to student assessment, teachers of each of the Science courses tested were surveyed. No survey was conducted for the Chemistry 200 and 300 Comparison testing. The data provided by experienced and well-informed educators in the field provide Manitoba Education and Training with valuable information for curriculum improvement.

The nine areas in which teachers were asked to provide information were: Teacher Background, School Organization, School Facilities, Manitoba Curriculum Guide, Teaching Resources and Materials, Teaching Activities and Methodology, Evaluation, Student Extra-Curricular Activities, and Future Directions (teaching of the particular Science course).

Questionnaires were sent to a sample of teachers for each of Science 100, Biology 200 and Physics 300. All teachers in Sciences 100 (Français and Immersion) and Physique 300 were surveyed. The information collected from each survey was used by the TAC in formulating meaningful recommendations.

CHAPTER 3

Science 100 (English)

DISCUSSION OF RESULTS

STUDENT RESULTS

The Science 100 English language test consisted of eight subtests: three compulsory core topics, four required options, and one additional option. Students were expected to answer all 50 questions in the core topics which included: Measurement and Experimentation, Characteristics of Matter, and Separation of Substances. In addition, students were expected to answer all the questions in the option(s) they had studied. The required options included the topics: Fossil Fuels, Motion and Collisions, Cells, and Nutrition. The only additional option topic that was tested was Particle Theory. Each subtest consisted of multiple choice items and written response questions.

The table that follows summarizes the performance of students on all subtests.

Table 1

MEAN PERFORMANCE ON SUBTESTS

SUBTEST		NO. OF STUDENTS RESPONDING	TOTAL POSSIBLE MARKS PER SUBTEST	MEAN RAW SCORE	MEAN PERCENT	STANDARD DEVIATION RAW SCORE
1. MEASUREMENT. . .	(MULTIPLE-CHOICE)		10	6.95	69.52	1.70
MEASUREMENT. . .	(WRITTEN-RESPONSE)	568	2	0.69	34.51	0.73
MEASUREMENT AND EXPERIMENTATION	(TOTAL)		12	7.64	63.69	2.04
2. CHARACTERISTICS. . .	(MULTIPLE-CHOICE)		17	10.00	58.84	3.20
CHARACTERISTICS. . .	(WRITTEN-RESPONSE)	568	8	4.39	54.93	2.50
CHARACTERISTICS OF MATTER	(TOTAL)		25	14.40	57.59	4.99
3. SEPARATION. . .	(MULTIPLE-CHOICE)		13	7.52	57.83	2.63
SEPARATION. . .	(WRITTEN-RESPONSE)	568	11	4.55	41.39	2.33
SEPARATION OF SUBSTANCES	(TOTAL)		24	12.07	50.29	4.23
E. FOSSIL FUELS	(MULTIPLE-CHOICE)		6	3.55	59.24	1.48
FOSSIL FUELS	(WRITTEN-RESPONSE)	229	4	2.24	56.11	1.19
FOSSIL FUELS	(TOTAL)		10	5.80	57.99	2.22
F. MOTION. . .	(MULTIPLE-CHOICE)		5	3.22	64.38	1.11
MOTION. . .	(WRITTEN-RESPONSE)	224	5	1.91	38.13	1.39
MOTION AND COLLISIONS	(TOTAL)		10	5.13	51.25	1.96
G. CELLS	(MULTIPLE-CHOICE)		11	7.63	69.32	1.94
CELLS	(WRITTEN-RESPONSE)	350	8	4.84	60.54	2.17
CELLS	(TOTAL)		19	12.47	65.62	3.43
H. NUTRITION	(MULTIPLE-CHOICE)		7	3.92	55.93	1.38
NUTRITION	(WRITTEN-RESPONSE)	153	11	4.42	40.17	2.30
NUTRITION	(TOTAL)		18	8.33	46.30	2.97
J. PARTICLE THEORY	(MULTIPLE-CHOICE)		13	7.84	60.31	2.72
PARTICLE THEORY	(WRITTEN-RESPONSE)	270	8	3.28	40.97	1.97
PARTICLE THEORY	(TOTAL)		21	11.12	52.95	4.15

Measurement and Experimentation

Upon reviewing the results, the Technical Advisory Committee rated the overall performance of students on this subtest as satisfactory. The performance on the multiple choice items was rated as more than satisfactory, while the performance in the shorter written response section was rated as unsatisfactory.

The students demonstrated a very good knowledge of the scientific process, particularly with respect to controlling of variables in an experiment. Eighty percent (80%) of the students answered items 3 and 8 correctly.

3. *Jim wanted to determine if temperature has an effect on the growth of bread mould. He grew the mould in nine containers each with the same amount and type of bread.*

Three containers were kept at 5°C.
Three containers were kept at 25°C.
Three containers were kept at 90°C.

The containers were examined at the end of four days.

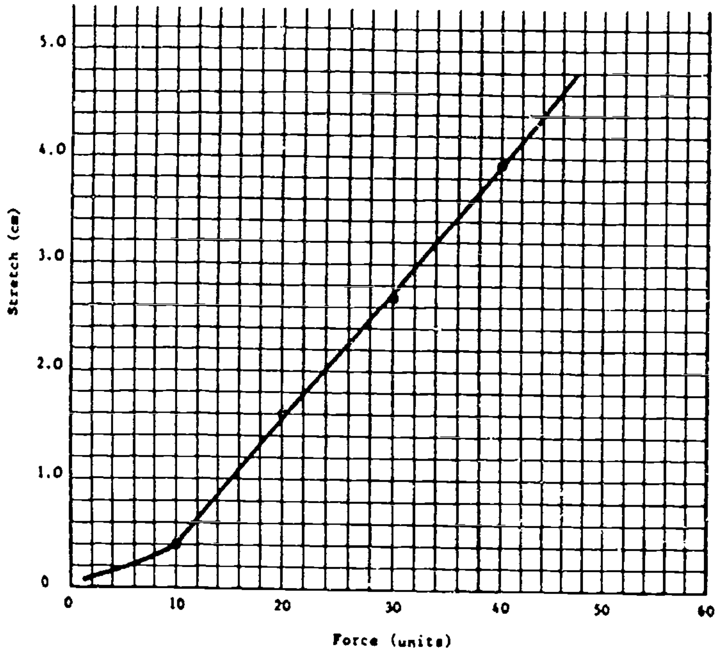
What is the main factor Jim should look for?

6.9%	A)	changes in the amount of bread in each container
79.4	* B)	the amount of growth of bread mould
1.8	C)	numbers of containers at each temperature
11.6	D)	differences in the temperature of the containers

USE THIS INFORMATION TO ANSWER QUESTIONS 6-8.

A student applied force to elastic bands and recorded the amount of stretch caused by various forces. The graph of the student's results is shown below.

Graph of Stretch versus Force for an Elastic Band



8. *Which of these variables must be controlled during this experiment if several elastic bands were used?*

3.2%	*A) thickness of the elastic band, only*
7.0	*B) original length of the elastic band, only*
0.7	*C) temperature, only*
8.8	*D) the length of stretch of elastic band, only*
80.1	* *E) thickness, original length of the elastic band, and temperature*

It was noted that students still have trouble with higher level thinking problems. This was evident in test item 5.

5. *A volume of 35 mL of water is added to 40 Ml of dry sand for a total volume of 60 ML What is the volume of sand particles alone?*

6.2%	*A) 5 Ml*
22.5	*B) 15 Ml*
10.0	*C) 20 Ml*
40.3	* *D) 25 Ml*
20.4	*E) 40 Ml*

Only 40.3% of the students answered this question properly. Perhaps, the difficulty arose in that students were generally looking for a formula to solve problems and this question could not be solved by any magical formula.

Characteristics of Matter:

The performance on the multiple choice items on this subtest was rated as satisfactory, while the performance on the written response questions was rated as adequate. The Technical Advisory Committee considered the overall performance on this subtest satisfactory.

Students seemed to be quite adept at using the formula "$D = \frac{m}{v}$" and could manipulate the formula in order to solve for either volume or mass if the other variables were given. This was illustrated in question 13, as 58% of the students answered this question correctly.

13. When 1.0 cm^3 of water, which has a mass of 1.0 g, is boiled, it will change to steam and the volume will increase to 1700 cm^3. Which of the following shows how the density of steam should be calculated?

57.9%	* A)	$\frac{1.0}{1700}$
4.6	B)	$\frac{100}{1700}$
16.9	C)	$\frac{1700}{1.0}$
3.0	D)	$\frac{1700}{100}$
17.3	E)	1700 x 1.0

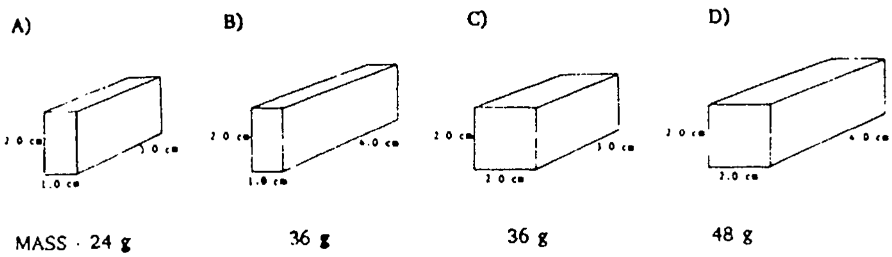
Similarly, in the written response section, approximately 60% of the students received the full three points for question 43 while another 18% received two points.

> 43. *A rectangular block measures 3.0 cm x 3.0 cm x 10.0 cm. Its mass is 450.0 g. Calculate the density of this block.*

There was some concern that even though students realized that "$D = \frac{m}{v}$", it was obvious that the actual understanding of density was weak. This fact was particularly illustrated in item 17 which was answered correctly by only 18.5% of students.

Use the following information to answer questions 16-17.

Four waterproof solid blocks are cut to the various dimensions shown below. The mass of each is given below the drawing.



> 17. *If a 1 cm^3 chunk is cut from each block and the masses compared on a balance, the chunk with the greatest mass would come from block*

5.5%	*A)*	*A.*
18.5	** B)*	*B.*
4.8	*C)*	*C.*
69.2	*D)*	*D.*

It appears that students did not realize that the mass of a 1cm^3 chunk of the block was actually the density of the block. Almost 70% of the students chose block D which was simply the block with the greatest mass.

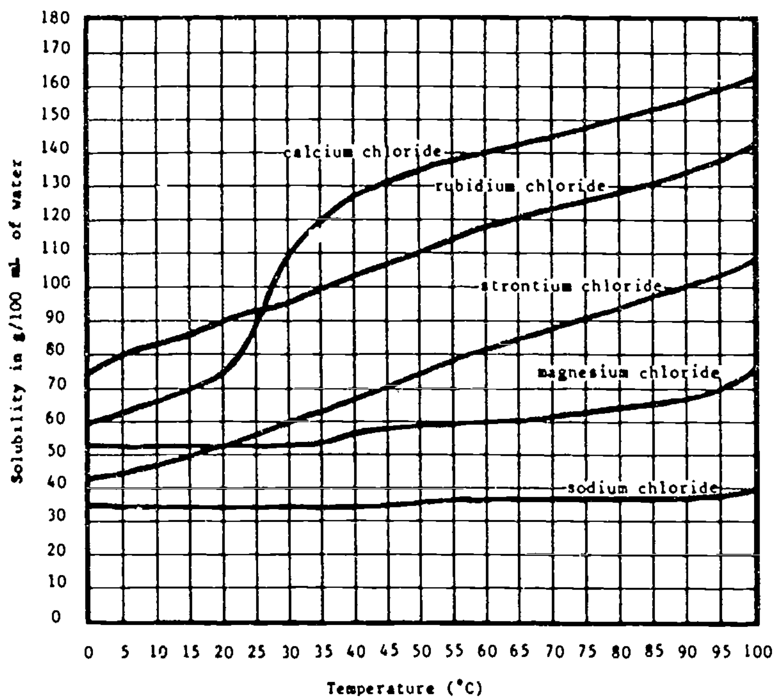
<u>Separation of Substances</u>

The student performance on this subtest was consistent in both the multiple choice and written response components (see Table 1 on page 7). The Technical Advisory Committee felt that the mean performance was satisfactory.

Students demonstrated strong skills in reading graphs. Examples were noted in question 30 which 88% of the students answered correctly and question 48 for which 74% of the students received full or partial credit.

Use this graph to answer questions 30-35.

Solubility Curves of Chlorides



30. *What is the solubility of magnesium chloride in water at 85°C?*

5.8%	*A)*	*55 g/100 mL*
3.0	*B)*	*60 g/100 mL*
88.2	** C)*	*65 g/100 mL*
1.9	*D)*	*85 g/100 mL*
0.7	*E)*	*95 g/100 mL*

48. *Kerry performs an experiment to determine the solubility of a salt in 100 mL of water at different temperatures. She records the following data:*

Solubility	*Temperature*
35 g/100 mL	*0°C*
40 g/100 mL	*10°C*
50 g/100 mL	*25°C*
80 g/100 mL	*40°C*
120 g/100 mL	*60°C*
190 g/100 mL	*80°C*

Produce a graph of the solubility curve for these data on the graph paper (grid) below. Let the vertical axis represent solubility and the horizontal axis represent temperature.

It was evident that students were able to construct a proper scale on an axis and also were able to plot points correctly. A weakness was detected in students' understanding that a 'best fit' curve should be drawn through the points instead of simply connecting the points.

The students' performance on question 31 was poor (44%).

31. *What mass of sodium chloride is required to saturate 10 mL of water at 100°C?*

7.0%	*A)*	*3.0 g*
12.1	*B)*	*3.5 g*
44.2	** C)*	*4.0 g*
13.9	*D)*	*35.0 g*
22.5	*E)*	*40.0 g*

The responses to this question illustrated that a large number of students could read the graph but about one-third of the students did not convert their answers to the correct volume of the solvent. Perhaps, this illustrates that students encountered difficulty working with fractions or ratio and proportion. There could have been an element of carelessness on the part of the students.

The Technical Advisory Committee was concerned that only 30% of the students could cite two safety factors in item 50 with another 36.8% citing one factor. At least one-third of the students was unable to cite a factor.

Use this information to answer questions 49 and 50.

Suppose you were given a mixture of solids containing powdered limestone, powdered table salt, and powdered naphthalene moth flakes.

Substance	*Colour*	*Solubility*	
		Water	*Alcohol*
Limestone	*White*	*Insoluble*	*Insoluble*
Salt	*White*	*Soluble*	*Insoluble*
Moth Flakes	*White*	*Insoluble*	*Soluble*

50. State two safety precautions that should be observed.

i) ______________________

ii) ______________________

This could suggest that students did not take written response items seriously or safety procedures were not strongly emphasized in school programs.

Fossil Fuels

The overall student performance on this subtest was rated as adequate. Considering that fossil fuels are non-renewable resources and are responsible for many of our environmental problems, the committee was concerned with the quality of some responses in this option. The Committee also noted that the ISIS text is badly outdated in this area.

In reviewing the responses to items 51 and 52, the Technical Advisory Committee was alarmed that only 44% of the students knew the major elements in crude oil, and only 50% of the students actually knew the major elements responsible for acid rain. Considering our present emphasis on the environment, is the relationship between the burning of fossil fuels and its impact on the environment emphasized enough in the teaching of this unit?

51. Crude oil is a mixture of many compounds. Most of these compounds are composed of the two elements

20.6%	*A)*	*hydrogen and oxygen.*
5.2	*B)*	*sulphur and oxygen.*
44.6	*C)*	*carbon and hydrogen.*
18.4	** D)*	*carbon and oxygen.*
10.9	*E)*	*nitrogen and sulphur.*

52. *Two elements, contained in crude oil and coal, which produce acid rain are*

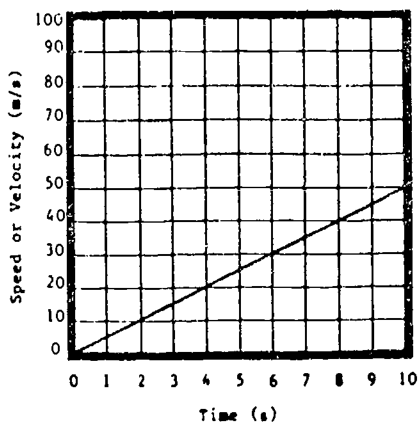
1.0%		*A) hydrogen and oxygen.*
24.1		*B) sulphur and hydrogen.*
14.9		*C) carbon and hydrogen.*
7.9		*D) carbon and oxygen.*
52.1	*	*E) nitrogen and sulphur.*

Motion and Collisions

The performance on the multiple choice segment of this subtest was rated as satisfactory, while the performance on written response items was rated as unsatisfactory. The Technical Advisory Committee considered the performance of students on this subtest as adequate.

The student performance on question 64 was impressive (55%) considering its difficulty level. Again, the results on this question confirmed the ability of students to read and interpret graphs.

64. *Graph of Speed vs. Time for an Object*



What is the acceleration of the object in the graph above?

6.3%		*A) 0.2 m/s²*
55.0	*	*B) 5 m/s²*
14.2		*C) 10 m/s²*
4.6		*D) 20 m/s²*
19.3		*E) 50 m/s²*

The student performance on question 68 was poor (22.8%).

> *68. A 1000 kg automobile is at rest. After 5 seconds, it is travelling 72 km/h (20 m/s). Calculate the acceleration of the automobile in m/s^2.*
> (Answer = 4 m/s^2)

It seems that very little emphasis was placed on the mathematical aspect of this unit. Perhaps this was due to time constraints as expressed by several teachers in the Teacher Questionnaire.

Cells

It appeared that this was the most popular option and also the option in which student performance was at the highest level.

The competency level of the students on the multiple choice items was rated as more than satisfactory (70%) while the proficiency level of the students in the written response component was rated as satisfactory (61%). The overall rating of student performance on this subtest was considered to be more than satisfactory.

The Technical Advisory Committee was slightly concerned with the student response to question 82.

> *82. State four (4) warning signals of cancer.*

Even though approximately 65% of the students could state 3 or 4 warning signals of cancer, the Committee thought that most of the students should be able to give at least four of the warning signals of cancer. After all, there are actually 7 warning signals of cancer, and the major objective of this unit is to make students aware of body changes that might indicate the presence of cancer.

Nutrition

The multiple choice component of this subtest was rated as adequate, while the proficiency on the written response items was rated as unsatisfactory. Consequently, the committee rated the overall student performance on this subtest as unsatisfactory. After looking at the results of this option, (see Table 1 on page 7) it appears that this was not only the least popular option, but was also the only subtest that received an unsatisfactory rating.

Only 21.5% of the students answered question 93 correctly.

93. How many regular calories or joules are required to raise the temperature of 200 grams of water from 25°C to 35°C?

(Specific heat capacity of water is 1 calorie/g°C or 4.2 J/g°C.)

2.6%	*A)*	*2 cal (8.4 J)*	
34.5	*B)*	*10 cal (42 J)*	
26.0	*C)*	*20 cal (84 J)*	
13.0	*D)*	*200 cal*	*(840 J)*
21.5	** E)*	*2000 cal*	*(8400 J)*

This illustrated that most students had little knowledge of the calculation of energy in calories or joules.

The members of the Technical Advisory Committee were concerned with the quality of responses as well as the lack of responses to item 99.

State two major medical health hazards of crash diets. Explain why each may be hazardous to your health.

99. Hazard 1: ______________________________

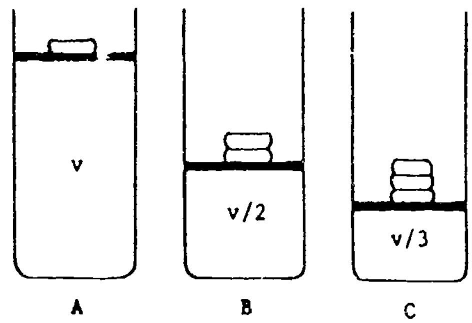
Students had great difficulty listing two medical health hazards of crash diets and had even greater difficulty in explaining why each may be hazardous to an individual's health. Considering the present incidence of anorexia and bulimia in our teenage population, one would think that this problem should be addressed and emphasized in this unit whereby students would recognize the potential hazards of crash diets and the fact that crash diets could lead to eventual eating disorders. Perhaps, this unit was treated casually because teachers believed that the concepts in this option overlapped with earlier Health and Human Ecology courses.

Particle Theory

In reviewing the results of this subtest, the Committee was mindful of the fact that this option was the most difficult in that it contained more abstract thinking and higher level analytical problems. The student performance on the multiple choice items was deemed satisfactory while the performance rating on the written response component was considered to be adequate. Overall, the student proficiency rating on this subtest was regarded as satisfactory (see Table 1 on page 7).

Students seemed to have had a fair understanding of the particle nature of matter. Approximately 60% of the students answered question 121 correctly.

Use the diagram below to answer questions 120-122.



121. Which container has the greater number of helium molecules?

22.9%	*A)*	*A*
3.3	*B)*	*B*
11.1	*C)*	*C*
60.0	** D)*	*all the same*

The response to this item indicated that most students could relate mass to number of particles and were well aware of the compressibility of gases and its relationship to the large amount of space between the particles of the gas.

The Committee expressed some concern with the students' lack of understanding of diffusion as indicated by the low performance on questions 111 and 112 (51%, 55%).

111. Which of the following statements is the <u>best</u> definition of diffusion?

12.2%	*A)*	*the movement of particles*
12.6	*B)*	*the movement of particles through an opening*
51.5	** C)*	*the spreading or intermingling of one substance with another*
4.8	*D)*	*the speed at which particles move*
17.5	*E)*	*the collision of one particle with another*

112. Diffusion occurs most rapidly in a

3.8%	*A)*	*solid-solid mixture.*
13.0	*B)*	*solid-liquid mixture.*
12.2	*C)*	*liquid-liquid mixture.*
14.5	*D)*	*liquid-gas mixture.*
55.1	** E)*	*gas-gas mixture.*

In general, the Technical Advisory Committee was impressed with the performance on this subtest and concluded that the teachers may have placed greater emphasis on this option as compared to some of the ISIS options.

General Conclusions

1. The Technical Advisory Committee rated the overall performance on the core topics as satisfactory to good. Perhaps one of the reasons that students performed well on the core topics is that the course is activity oriented.

2. The performance on questions relating to reading, interpreting and constructing graphs was rated as good. Students' understanding of graphing in general was very good. This was viewed as being very positive in that graphic illustrations are used widely in everyday situations.

3. The majority of students could calculate density by using the formula $D = \frac{m}{v}$. The results also indicated that the students could satisfactorily manipulate the formula and solve for the unknown variable if the other two variables were given. The performance on this concept appeared weak when the students had to demonstrate an understanding of density. Density is really a ratio or a fraction, and even though students knew the definition of density as the ratio of mass to volume, the understanding of ratio and proportions was not satisfactory.

4. The relationship of the science concepts or principles in the ISIS modules to every day situations, technology, and the environment was either not stressed by teachers or not well understood by the students. (Nutrition and Fossil Fuels)

5. Most calculation and quantitative questions in the option units were not done well. It was suggested that one of the reasons for the low performance is that the option topics are usually taught at the end of the course. Therefore, the topics may have been covered superficially because of time constraints.

6. In the Committee's view the only negative aspect of the overall results was the fact that the written response component of the test was frequently not attempted. This made it difficult to compare student performance on questions relating to the same topics in both the multiple choice and written response components of the test. Perhaps, one reason the students did not attempt written response questions is that they experience difficulty in verbalizing or articulating their answers. Another reason for ignoring written response items was that students did not take the test seriously as it would have had no impact on their final grade.

TEACHER SURVEY RESULTS

The Teacher Questionnaire provides Manitoba Education and Training with many opinions from teachers on various aspects of teaching and learning Science 100 in Manitoba. These opinions could be utilized by Manitoba Education and Training in future planning of Science 100 courses and selecting of textbooks or laboratory materials. The Questionnaire data also assist in the better interpretation of student results.

There were nine areas in the Teacher Questionnaire in which information was sought. They were:

i. Teacher Background
ii. School Organization
iii. School Facilities
iv. Curriculum Guide
v. Teaching Resources and Materials
vi. Teaching Activities and Methodology
vii. Evaluation
viii. Student Extracurricular Activities Related to Science 100
ix. Future Directions

This report summarizes the comments of 216 out of 243 teachers of Science 100 who completed the Questionnaire. In almost every instance teachers left some questions unanswered, but for the purposes of the report, the number of responses per item was converted to a percentage based on the number of questionnaires returned.

I. TEACHER BACKGROUND

Eighty point six percent (80.6%) of Science 100 teachers in Manitoba have more than one credit in Chemistry at the university level. Fifty-five point six percent (55.6%) of them took more than one course in Biological sciences, and 48.6% have more than one credit in Physics. Sixty-eight point one percent (68.1%) of Science 100 teachers in Manitoba have more than one credit in Mathematics at the university level.

Fifty-six percent (56%) of the respondents have taught Science 100 for more than seven years. Even though few teachers in Science 100 have taken university courses in the last five years, approximately 50% have attended either workshops or seminars related to the teaching of Science 100.

II. SCHOOL ORGANIZATION

More than half of the respondents taught in a semester system. Only 15.3% of teachers taught combined Science 100 and 101 classes. On the average, teachers have approximately 110 hours of instructional time to teach the Science 100 course.

III. SCHOOL FACILITIES

Eighty-eight percent (88%) of teachers teach Science 100 in a science laboratory or combination classroom/laboratory setting. Eighty-four point three percent (84.3%) of respondents indicated that they have lab facilities available to them for more than 60% of instructional time.

The majority of lab facilities (91%) included tables/counters, adequate storage room for science materials and equipment, adequate work space for students, hot and cold water outlets with sinks, electrical outlets, adequate lighting, and propane/natural gas outlets.

Most laboratory rooms (92%) contain eye-wash stations, master gas shutoff, fire blanket, safety goggles, and fire extinguishers. Only 56.9% of rooms have a first aid kit and only 30.6% have a deluge shower.

Very few teachers (21%) have a lab assistant for Science 100.

IV. CURRICULUM GUIDE

Ninety-four point nine percent (94.9%) of teachers use the curriculum guide and 87.5% placed moderate to great emphasis on the objectives in the guide.

All options listed in the curriculum guide were taught by different teachers. Cells and Cancer was the most popular option (73% of teachers) while Air and its Components seemed to be the least popular option (11% of teachers).

V. TEACHING RESOURCES AND MATERIALS

The majority of teachers (66%) use the textbook, *Physical Science, an Introductory Study* by W. A. Andrews et al, Prentice-Hall, to teach the compulsory topics in Science 100. Another text that is used quite extensively is *Introductory Physical Science* by U. Haber-Schaim et al, Prentice-Hall. Both of these textbooks are also used by many teachers in teaching some of the options.

Several ISIS textbooks are used extensively to teach many of the options. Some of the texts are *Packaging Passengers*, *Let's Eat*, *Cells and Cancer*, and *Fossil Fuels*.

VI. TEACHING ACTIVITIES AND METHODOLOGY

All teachers include the following in their teaching methods to different degrees: lecture, teacher demonstrations, student-performed laboratory activities, and individualized instruction.

There appears to be a heavy emphasis on student-performed lab activities in Science 100. Almost 50% of teachers indicate that student-performed lab activities take up 40% to 60% of instructional time.

VII. EVALUATION

Most of the teachers evaluate students' performance on teacher-made tests which include multiple choice, true-false or matching items, non-numeric questions of recall, non-numeric questions of application and explanations, and lab skills items.

Ninety-four point four percent (94.4%) of teachers indicated that their students write final exams and 36.1% allow exemptions.

Fifty-nine point seven percent (59.7%) of teachers indicated that they mark each student's lab report for all lab activities.

VIII. STUDENT EXTRACURRICULAR ACTIVITIES RELATED TO SCIENCE

Thirty-five point two percent (35.2%) of teachers do not provide any opportunities for students to participate in science-related activities outside of Science 100 classes. Forty-seven point two percent (47.2%) of respondents stated that their students participated in Science fairs.

Some science-related tours/field trips available to Science 100 students were visits to:

- hospital facilities
- Labatt's Brewery
- water treatment plant
- Mohawk Ethanol plant (Minnedosa)
- Whiteshell Nuclear Research Center

- Abitibi and Price Paper Mill
- REPAP (wood processing)
- Flin Flon (smelting)
- waste management and treatment plant.

IX. FUTURE DIRECTIONS

Teachers have varied views as to what the Science 100 course is to accomplish in the future. In order to improve their teaching and prepare students for the 21st century, the teachers recommended:

a) that the course be more rigorous and quantitative (22%).

b) that the course be revised in order to include one-third Chemistry, one-third Physics, one-third Biology (17%).

c) that the ISIS materials be eliminated from the course because these materials are not rigorous enough to challenge a Science 100 student (11%).

d) that Particle Theory be added to the list of compulsory topics (18%).

e) that the compulsory topics be retained, but new optional topics be designed so as to reflect present-day concerns such as sustainable development strategies (14%).

Recommendations

The recommendations that follow are based on the results of the Science 100 assessment and the insights of teachers on the Technical Advisory Committee. These recommendations have implications for specific target groups or their implementation may entail overlapping responsibilities with other groups. The letter(s) at the end of each recommendation indicates the group(s) to which it is principally directed. This legend provides the letter symbol for each target group:

Manitoba Education and Training	= M
Teachers	= T
School Divisions and Administrators	= S
Faculties of Education	= F

The Science 100 curriculum consists of five Optional topics. The student results reveal that all the Optional topics are taught but Cells and Cancer and Particle Theory appear to be the two most popular ones (see Table 1 on page 7). Actually, students performed best on Cells and Cancer and it was the opinion of several teachers (22%) that this topic could be covered in Grade 9 (Senior I). Particle Theory provides a greater challenge for students in abstract thinking and higher order thinking skills which, in turn, provide a good foundation for later study in Science. Twenty-two percent (22%) of the teachers surveyed suggest that Particle Theory be added to the list of Core topics. Therefore, it is recommended that:

1. **the present Core topics be retained but add Particle Theory to the list with continued emphasis on laboratory activities and skills. (M, T)**

A fair number of the teachers surveyed (22%) would like to see a more rigorous Science 100 course, a course with more emphasis on Physics and Chemistry. This may require the extension of the compulsory topics and a de-emphasis of Optional topics like Nutrition which can be incorporated into Home Economics or Health studies. It is the favoured opinion (26%) of the teachers surveyed that too much of the present content is a repeat of ideas taken in Junior High even though the student results may not reflect the easiness of the program. The Technical Advisory Committee surmises that the program lacks challenge. As such, it is recommended that:

2. **the materials and resources for Optional topics be reviewed in order to provide a greater challenge to Science 100 students. (M)**

3. **the inclusion of Core and Optional topics in the Science 100 course consider those that reflect present-day concerns like sustainable development, pollution and health-related issues (cancer, AIDS, etc.) (M)**

The student results show low performance for almost all written-response questions. Based on the review of these results and that of the teacher survey which indicates that teachers wish to provide more opportunities for students to do problem solving and write-up their solutions, the Science 100 Technical Advisory Committee recommends that:

4. **teachers provide their students with increased opportunities for recording written solutions and explanations of processes used in problem solving and completing long answer questions on tests. (T)**

5. **Faculties of Education emphasize the importance of language structure in long answer questions on assessment in all science courses when preparing teacher trainees on Student Evaluation. (F)**

Even though few teachers (5 out of 216) made specific comments on the expectations of university courses in Science Education, the Technical Advisory Committee felt that it was important for the Faculty of Education to offer a course specific to the teaching of Science 100. This particular course is a mixture of Chemistry, Physics and Biology and is activity-oriented. It is anticipated that the course would not deal merely with science content but with teaching methodologies and approaches as well. Thus, it is recommended that:

6. **the Faculties of Education develop special methodology courses for the teaching of specific high school science courses, for example, Science 100. (F)**

On average, teachers had 24 students in their Science 100 classes and spent an average of 7.5 hours per six-day cycle in preparing laboratory activities and classroom lessons and in marking student laboratory reports, assignments and tests. Larger classes will require more time for these instructional activities, especially with classrooms of varied learning abilities. Therefore, it is recommended that:

7. **school divisions maintain class sizes in Science 100 to a maximum of 25 students in order to administer a basically laboratory-oriented program. (S)**

A substantial number of teachers surveyed indicated that their laboratory facilities may not have the required safety equipment. For example, only 20.4% confirmed that there is a main power switch (CFCI or Grand Fault Circuit Interrupt) in their laboratory; 34.3% claim they have safety goggles; 56.9% have an approved First Aid kit; 30.6% have a deluge shower; and 55.6% have a fume hood. Based on the lack of proper safety measures in some laboratory facilities, it is recommended that:

8. **all laboratory facilities meet the safety requirements of Workplace Hazardous Material Information System, and schools be provided with appropriate support to satisfy the regulations. (S)**

In reviewing the pattern of responses for the written-response questions, the Technical Advisory Committee noted that student performance was generally weak. While the Committee felt the poor results might have been attributed to a lack of importance that was attached to the testing or the basic lack of skills and knowledge on the part of students, the members think it is important to provide a good Science foundation for students continuing with further study in Science. Consequently, they suggest that:

9. **teachers provide or continue to provide activities in which discussion and in-depth written responses are used to promote the application of knowledge. (T)**

10. **teachers continue emphasizing problem solving skills and transfer of laboratory understanding to theory. (T)**

11. **teachers emphasize the use of scientific terminology in all instructional activities. (T)**

12. **teachers be more demanding of detail in laboratory reports and written responses. (T)**

CHAPTER 4

Biology 200 (English)

DISCUSSION OF RESULTS

STUDENT RESULTS

The assessment of Biology 200 was conducted only in the English language stream and consisted of the core topics only. The 20% provincial sample consisted of students who were enrolled in a full-year or second-semester program. The test consisted of multiple choice items and long-answer type questions. Table 2 below shows the nine subtests with a breakdown of the mean performance of students. Homeostasis is listed as a separate component. Even though it is not identified in the Curriculum Guide as a separate unit, it is a repetitive theme that occurs in several units (Circulatory System, Respiratory System, Excretory System, Endocrine System, Nervous System, and Digestive System). As such, the Biology 200 Technical Advisory Committee felt that special emphasis should be given to homeostasis.

Table 2

MEAN PERFORMANCE ON SUBTESTS

	SUBTEST		TOTAL POSSIBLE MARKS PER SUBTEST	MEAN RAW SCORE	MEAN PERCENT	STANDARD DEVIATION RAW SCORE
I.	CELL STRUCTURE AND FUNCTION	(MULTIPLE-CHOICE)	18	9.78	54.32	3.22
	CELL STRUCTURE AND FUNCTION	(WRITTEN-RESPONSE)	5	1.49	29.77	1.18
	CELL STRUCTURE AND FUNCTION	(TOTAL)	23	11.27	48.99	3.82
II.	BIOCHEMISTRY	(MULTIPLE-CHOICE)	20	10.06	50.28	3.62
	BIOCHEMISTRY	(WRITTEN-RESPONSE)	3	0.63	21.03	1.03
	BIOCHEMISTRY	(TOTAL)	23	10.69	46.47	4.22
III.	DIGESTION	(MULTIPLE-TOTAL)	13	6.42	49.41	2.62
IV.	TRANSPORTATION	(MULTIPLE-CHOICE)	17	9.12	53.62	3.53
	TRANSPORTATION	(WRITTEN-RESPONSE)	10	2.85	28.46	2.13
	TRANSPORTATION	(TOTAL)	27	11.96	44.30	4.94
V.	RESPIRATORY SYSTEM	(MULTIPLE-TOTAL)	5	2.30	46.09	1.32
VI.	EXCRETORY SYSTEM	(MULTIPLE-TOTAL)	8	3.88	48.51	1.87
VII.	NERVOUS SYSTEM	(MULTIPLE-CHOICE)	9	3.86	42.90	2.16
	NERVOUS SYSTEM	(WRITTEN-RESPONSE)	9	2.49	27.63	2.29
	NERVOUS SYSTEM	(TOTAL)	18	6.35	35.26	3.92
VIII.	ENDOCRINE SYSTEM	(MULTIPLE-TOTAL)	6	2.73	45.50	1.47
IX.	REPRODUCTION AND DEVELOPMENT	(MULTIPLE-CHOICE)	13	5.44	41.87	2.75
	REPRODUCTION AND DEVELOPMENT	(WRITTEN-RESPONSE)	6	1.88	31.26	1.71
	REPRODUCTION AND DEVELOPMENT	(TOTAL)	19	7.32	38.52	3.87
	HOMEOSTASIS	(WRITTEN-TOTAL)	4	0.66	16.43	0.96

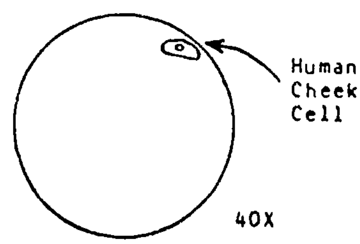
Number of students tested = 604

In addition to the testing of students, teachers were surveyed on various aspects of professional and instructional activities related to the Biology 200 program. Therefore, this report summarizes the student results by subtest and teachers' comments in the respective categories.

Cell Structure

In comparison to the other subtests the performance of students on this subtest was satisfactory. The mean percent of scores obtained by students was 49%. Their performance on the multiple choice items was better than their written responses. Questions dealing with the compound microscope were answered quite well. Seventy percent (70%) of the students answered question 6 correctly.

6. *A student observed a human cheek cell through a compound microscope as shown below. If she wanted to move the cell into the middle of the field, in which direction should she move the slide?*



21.5% A) 

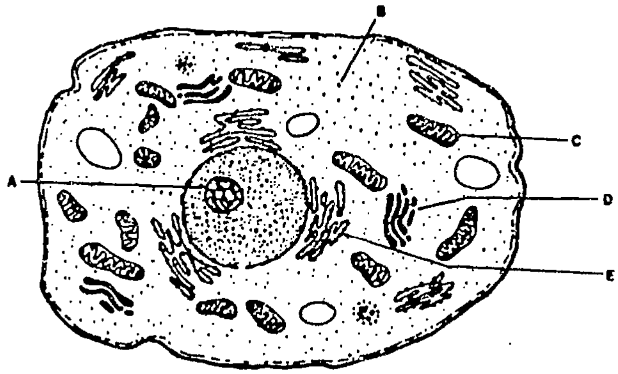
70.0 * B) 

4.3 C) 

4.1 D) 

Students were able to identify the parts of a cell satisfactorily. Sixty-six point two percent (66.2%) of the students answered question 9 correctly.

Use the diagram below to answer questions 9 and 10.



9. *Which structure is the endoplasmic reticulum?*

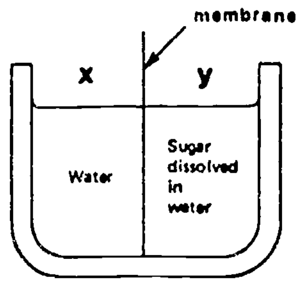
2.2%		*A)*	*A*
9.4		*B)*	*B*
7.0		*C)*	*C*
15.2		*D)*	*D*
66.2	*	*E)*	*E*

Osmosis was poorly understood. Only 31.5% of students answered question 14 correctly.

A mere 25.8% of students answered question 18 correctly.

Use the following information to answer questions 13 and 14.

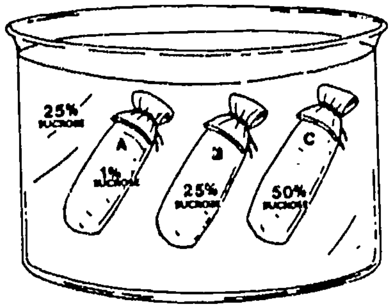
The container below is divided by a membrane that allows only water molecules to pass through.



14. *If you left this container for one hour, the level of liquid on side Y would be*

29.6%		*A)*	*the same height as the level of the liquid on side X.*
31.5	*	*B)*	*higher than the level of liquid on side X.*
27.6		*C)*	*lower than the level of the liquid on side X.*
10.8		*D)*	*impossible to predict from the information given.*

18. *An experiment was set up as shown below. Each bag and the beaker contain a solution of sucrose and water. Only water can pass through the bag membranes; sucrose cannot.*



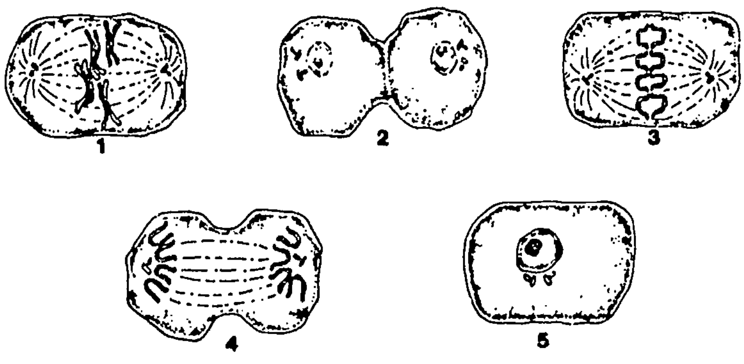
After one hour, which bag would increase in size?

33.3%	A)	A
2.5	B)	B
25.8	* C)	C
26.5	D)	A, B, and C will all increase in size.
11.8	E)	Impossible to predict from the information provided.

Some aspects of mitosis were well understood; others were not. Students were able to arrange a series of diagrams in the correct sequence but had difficulty explaining why mitosis is important for human beings. Seventy-three percent (73%) of students answered question 12 correctly.

Use the following diagrams to answer questions 11 and 12.

A Cell in Various Stages of Mitosis

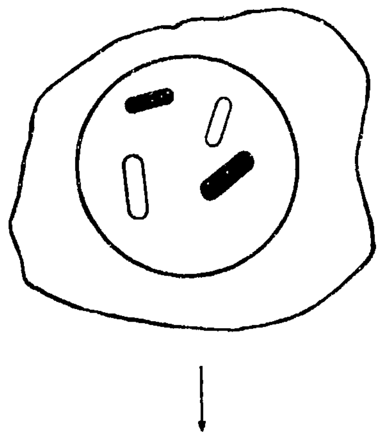


12. *What is the correct sequence for the diagrams above?*

3.3%	A)	5, 3, 1, 2, 4
5.8	B)	5, 2, 3, 4, 1
73.0	* C)	5, 1, 3, 4, 2
7.9	D)	5, 2, 4, 3, 1
9.8	E)	5, 4, 3, 1, 2

Sixty-five percent (65%) of students received full or partial marks on question 129.

129. The diagram below represents a cell which is about to undergo mitosis and cytokinesis (cell division). Draw the correct number of cells that would be formed when division is complete. Also show the number of chromosomes in each cell.



Only 22.5% of students answered question 130 correctly. Sixty-one point eight percent (61.8%) of students did not attempt the question.

130. Where does mitosis occur in the human body?

bone marrow cells or epithelial cells in skin or in lining of digestive tract (any one = correct)

Fifty-six percent (56%) of students received full or partial marks for question 131.

131. Why is mitosis important for human beings? Give two reasons.

Reason 1: replacing dead cells with similar ones;

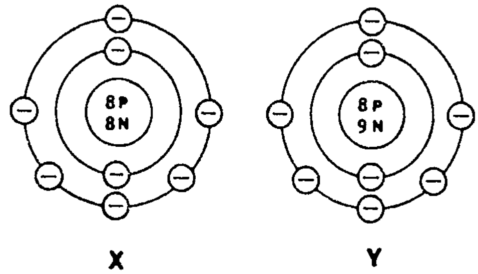
Reason 2: growth and development of the body or repairing damaged tissue

Biochemistry

In comparison to the other subtests, the overall performance of students in this subtest was barely adequate. The mean percent of student scores was 46%. Students were more successful in answering multiple choice items as compared to written response items.

Chemical bonding was poorly understood. Only 43% of students answered question 21 correctly.

Use the diagrams below to answer questions 19-21.



21. *How many electrons would structure X have to share with structure Y in order for them to bond together?*

20.9%	*A)*	*0*
26.3	*B)*	*1*
43.0	* *C)*	*2*
3.1	*D)*	*6*
6.6	*E)*	*8*

Thirty-three percent (33%) of students received full or partial marks for question 111. There was a variety of acceptable diagrams.

111. *In the space below draw a diagram that shows the formation of an ionic bond between a lithium atom and a fluorine atom. Be sure to indicate the resulting charges on the atoms.*

Type of atom	*Atomic number*	*Mass number*
Lithium	*3*	*7*
Fluorine	*9*	*19*

Students were able to interpret chemical formulae reasonably well. Sixty-nine percent (69%) answered question 27 correctly.

Use this chemical formula to answer questions 27 and 28.

$C_3H_5(OH)_3$

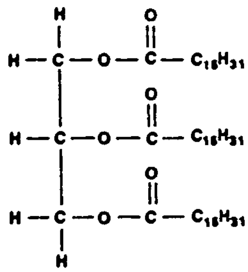
	27.		*How many different types of atoms are represented?*
2.0%		*A)*	*1*
69.0	*	*B)*	*3*
17.7		*C)*	*4*
11.1		*D)*	*more than 4*

Sixty-seven point seven percent (67.7%) answered question 28 correctly.

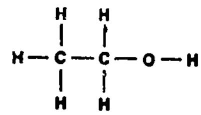
	28.		*What is the total number of hydrogen atoms in one molecule of this substance?*
2.0%		*A)*	*1*
2.3		*B)*	*2*
8.6		*C)*	*3*
19.4		*D)*	*5*
67.7	*	*E)*	*8*

Many students appear to have a superficial understanding of the chemistry concepts. Only 42.4% of students could identify the structural formula of glucose in question 31. Thirty-four point four percent (34.4%) of students answered question 33 correctly.

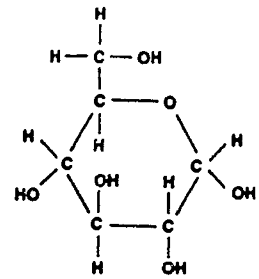
Use the following diagrams to answer questions 31 and 32.



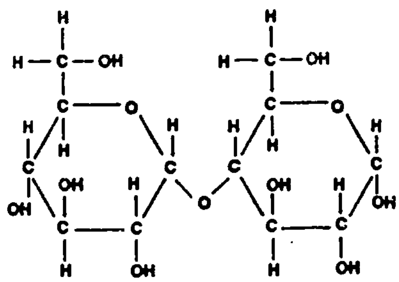
A



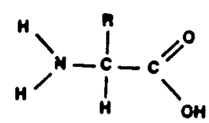
B



C



D

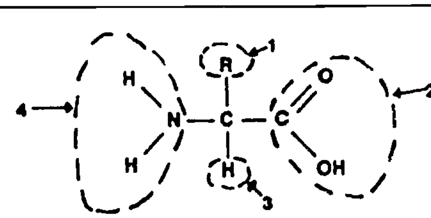


E

31. Which diagram is the structural formula of glucose?

4.6%		*A)*	*A*
26.3		*B)*	*B*
42.4	*	*C)*	*C*
15.1		*D)*	*D*
11.3		*E)*	*E*

Use the following diagram to answer questions 33 and 34.



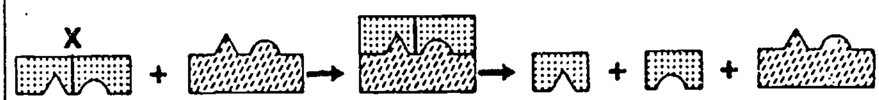
33. What type of food would have to be digested in order to produce the type of molecule that has been drawn above?

34.4%	*	*A)*	*protein*
19.4		*B)*	*fat*
18.7		*C)*	*carbohydrate*
17.2		*D)*	*starch*
10.1		*E)*	*sugar*

Enzymes were not well understood. Only 43.9% of students could identify the substrate in question 37.

Use the following diagram to answer questions 37 and 38.

An Enzymatic Reaction



37. The structure labelled X represents

34.8%		*A)*	*an enzyme.*
43.9	*	*B)*	*a substrate.*
6.3		*C)*	*an end product.*
14.6		*D)*	*an enzyme-substrate complex.*

Perhaps more instructional time should be spent on this unit. It is the opinion of the Technical Advisory Committee that the chemistry section should be taught early and reinforced throughout the remainder of the course.

Digestion

This subtest consisted only of multiple choice items. The test items required the recall of highly specific information and may have been somewhat more difficult than the multiple choice questions in other subtests. In comparison to the other subtests, the overall performance of students in this subtest was satisfactory. The mean percent was 49.4% which was somewhat close to the mean scores of the multiple choice component in other subtests (see Table 2 on page 27).

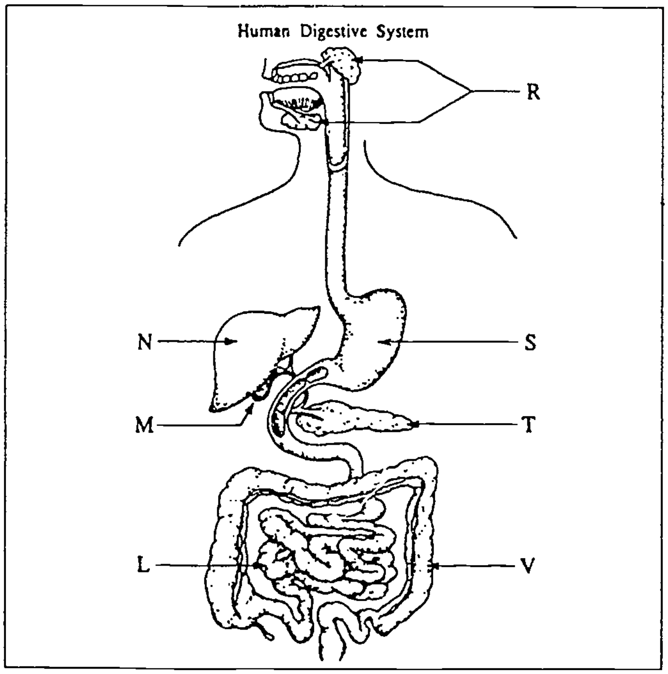
Students were able to answer some of the simpler questions. Seventy point two percent (70.2%) of the students answered item 51 correctly.

51. Food must be digested so that

70.2%	*	*A)*	*the food can be absorbed into the blood stream more easily.*
24.0		*B)*	*the food can pass through the digestive system more easily.*
5.1		*C)*	*a person does not become constipated.*
0.5		*D)*	*a person does not get diarrhoea.*

Seventy-nine point eight percent (79.8%) answered question 40 correctly.

Use the following diagram to answer questions 40 - 43.



40.		Which structure is the gallbladder?	
79.8%	*	A)	M
4.5		B)	N
1.5		C)	S
14.1		D)	T

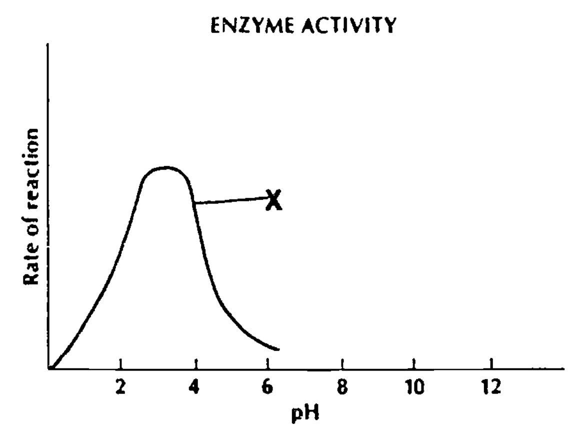
Fifty-nine point nine percent (59.9%) answered question 42 correctly.

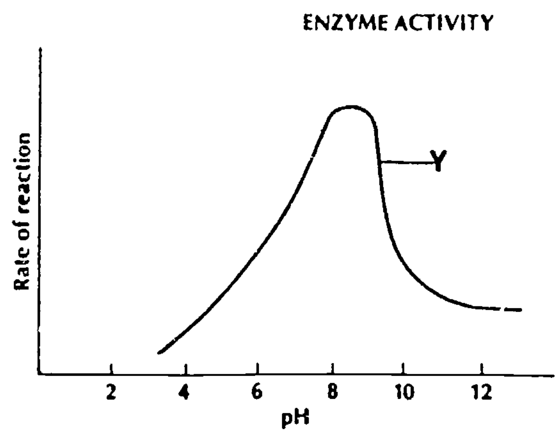
42.		Which would most likely result from the removal of the structure labelled V?	
16.2%		A)	incomplete digestion of fat
59.9	*	B)	reduced absorption of water
15.2		C)	incomplete digestion of protein
8.4		D)	reduced absorption of carbohydrates

Students were not as successful in answering questions which required highly specific information. This was evident in questions 48, 49 and 50. Only 41.2% answered question 48 correctly, 32% answered question 49 correctly, and 35.1% answered question 50 correctly.

Use the following graphs to answer questions 48-50.

The information used to construct the following graphs was obtained by studying two different digestive enzymes.





48. *What digestive secretion contains enzyme X?*

41.2%	*	*A)*	*gastric juice*
18.9		*B)*	*pancreatic juice*
15.4		*C)*	*intestinal juice*
23.8		*D)*	*bile*

49. *In which part of the human digestive system would you expect to find enzyme Y?*

33.6		*A)*	*stomach*
20.9		*B)*	*mouth*
32.0	*	*C)*	*small intestine*
13.1		*D)*	*gallbladder*

50. *Enzymes X and Y work on the same nutrient. What is that nutrient?*

12.1%		*A)*	*glucose*
13.7		*B)*	*lipid*
20.7		*C)*	*starch*
35.1	*	*D)*	*protein*
18.2		*E)*	*carbohydrate*

Perhaps, students should be provided with more learning activities where they can apply their biological knowledge to new situations.

Transportation

The overall performance of students on the multiple choice section of this subtest was satisfactory (mean percent was 54%). However, their responses to the long answer questions were inadequate (mean percent was 28%). The overall mean percent for this subtest was 44%.

Students were able to answer simple multiple choice questions reasonably well. Sixty point four percent (60.4%) answered question 54 correctly.

54.		*The vein whose blood has exactly the same composition as the aorta is the*
19.0%	*A)*	*superior vena cava.*
7.5	*B)*	*inferior vena cava.*
60.4	* *C)*	*pulmonary vein.*
12.9	*D)*	*renal vein.*

Seventy-three point five percent (73.5%) answered question 59 correctly.

Use the information below to answer questions 59 and 60.

Characteristics of Three Kinds of Blood Vessels

Vessel 1	*Vessel 2*	*Vessel 3*
- *smallest diameter*	- *no valves*	- *largest diameter*
- *no valves*	- *greatest elasticity*	- *valves present*
- *walls are one cell thick*	- *high blood pressure*	- *squeezed by contraction of skeletal muscle*

59.		*What is vessel 1?*
12.7%		*A) vein*
6.0		*B) artery*
73.5	*	*C) capillary*
7.8		*D) lymph vessel*

Seventy percent (70%) answered question 63 correctly.

63. The clotting of blood is initiated by

10.1%		*A) red blood cells.*
9.8		*B) white blood cells.*
70.0	*	*C) platelet.*
10.1		*D) plasma.*

Student responses to the long answer questions seem to indicate that they do not have a good understanding of how white blood cells protect humans from invading microorganisms. Forty-five percent (45%) of students received full or partial marks for question 112.

112. The circulatory system plays a very important role in helping to protect human beings from invading microorganisms. Describe two different ways in which the white blood cells assist in this process.

first way: Some white blood cells (phagocytes) surround invading microorganisms and ingest and digest them.

second way: Some white blood cells (lymphocytes) produce chemical (antibodies) which adhere to invading microorganisms and either destroy or help to inactivate them. Blood flows out of the wound and flushes away invading microorganisms.

They also do not understand the relationship between the lymphatic system and the blood circulatory system. Eighty-four percent (84%) received a mark of 0 for item 113.

113. Describe how the lymphatic system contributes to the functioning of the blood circulatory system.

Questions 117, 118 and 119 were poorly answered. Many students do not appear to understand the interrelationship between the blood circulatory system and the other systems of the body. Thirty-two percent (32%) of students answered item 117 correctly.

Use this information to answer questions 117 - 119.

The circulatory system provides nutrients and oxygen for the cells of the other body systems. There are additional functions the circulatory system performs for the other systems of the body.

117. Describe <u>one additional</u> way the circulatory system helps the digestive system?

Twenty-three percent (23%) of students answered item 118 correctly.

118. Describe <u>one additional</u> way the circulatory system helps the endocrine system.

Thirty-three percent (33%) of students answered item 119 correctly.

119. Describe <u>one additional</u> way the circulatory system helps the excretory system.

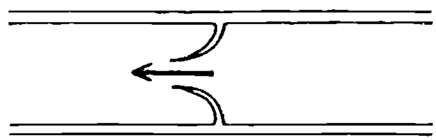
<u>Respiratory System</u>

The overall performance of students on this subtest was barely adequate. The mean percent was 46%.

Again, as in previous subtests, simple questions were answered reasonably well. Fifty-one point three percent (51.3%) of students answered question 61 correctly.

61.

A Longitudinal Section of a Blood Vessel



For this blood vessel, what is the correct direction of blood flow, the correct condition of the blood, and the correct type of blood vessel?

29.0%		*A)*	*away from the heart,*	*oxygenated,*	*pulmonary artery*
17.1		*B)*	*away from the heart,*	*deoxygenated,*	*pulmonary vein*
13.4		*C)*	*toward the heart,*	*oxygenated,*	*artery*
40.6	*	*D)*	*toward the heart,*	*deoxygenated,*	*vein*

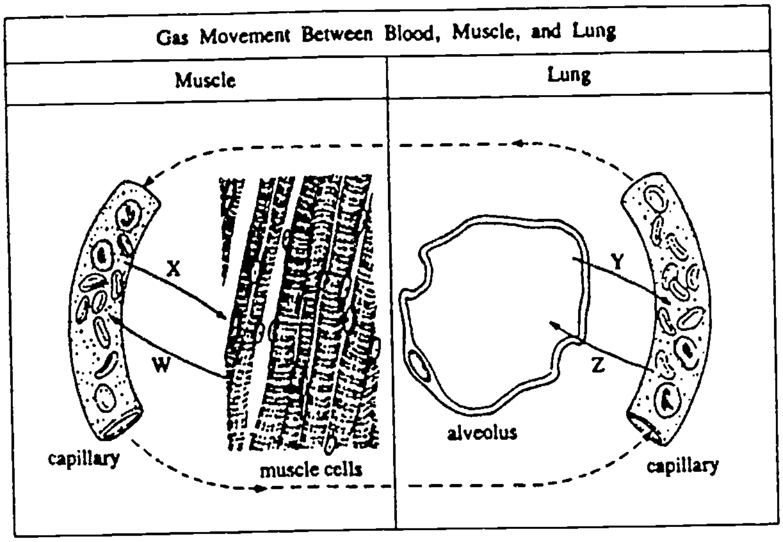
Fifty-four point three percent (54.3%) answered item 71 correctly.

71. ***Carbon dioxide is transported in human blood primarily by***

18.5%		*A)*	*red and white blood cells.*
54.3	*	*B)*	*red blood cells and plasma.*
16.6		*C)*	*white blood cells and plasma.*
8.8		*D)*	*platelet and plasma.*

However, students' ability to answer questions involving the synthesis of two or more related ideas is lacking. This is well illustrated in item 72 where only 38.6% of students obtained the correct answer.

72. *The labelled directional arrows represent the net movement of what gases?*



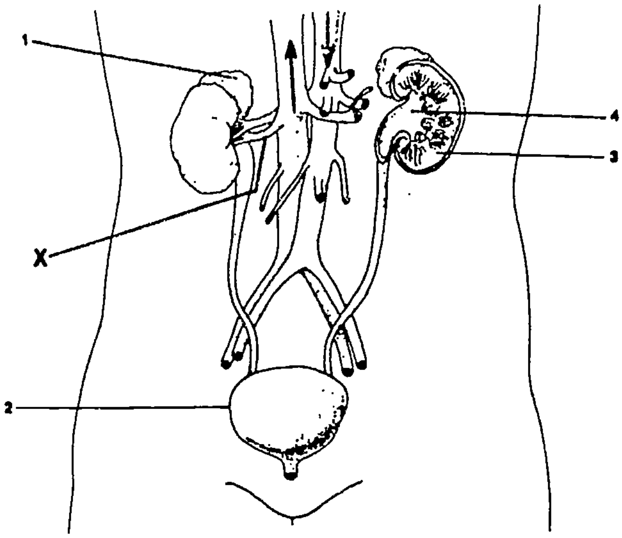
38.6%	* *A)*	*X and Y are oxygen*
12.4	*B)*	*X and Y are carbon dioxide*
36.6	*C)*	*X and Z are oxygen*
10.6	*D)*	*X and Z are carbon dioxide*

<u>Excretory System</u>

The performance of the students on this subtest was satisfactory. The mean percent was 49%.

Students were able to identify the basic structures of the human excretory system fairly well. Fifty-four point four percent (54.4%) answered item 74 correctly and 58.4% answered item 75 correctly.

Use the diagram below to answer questions 74 and 75.



74. *Nephrons may be found at location*

12.3%	A)	1.
11.4	B)	2.
54.4	* C)	3.
20.4	D)	4.

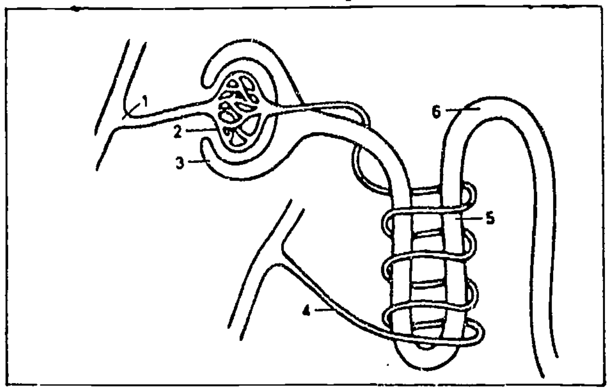
75. *Structure X is the*

24.3%	A)	renal artery.
58.4	* B)	renal vein.
9.3	C)	inferior vena cava.
6.1	D)	descending aorta.

Many students did not understand how the nephron functions. Thirty-seven point one percent (37.1%) answered item 78 correctly and 31% answered question 79 correctly..

Use the following diagram to answer questions 77-79.

Human Nephron



78. *The structure containing blood with the lowest concentration of urea is*

27.3%		*A)*	*1.*
10.3		*B)*	*2.*
37.1	*	*C)*	*4.*
22.8		*D)*	*5.*

79. *Which substance can be found in 1 but usually is NOT found in 3?*

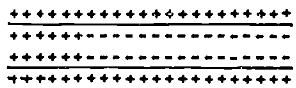
31.0%	*	*A)*	*blood protein*
15.2		*B)*	*water*
29.5		*C)*	*glucose*
22.7		*D)*	*mineral salts*

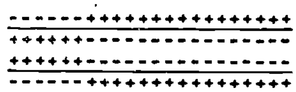
Nervous System

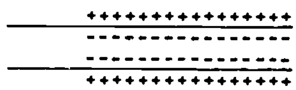
The overall performance of students on this subtest was unsatisfactory. The mean performance was 35%. This may be attributed to the fact that many teachers did not have time to teach this unit (as determined from teacher surveys).

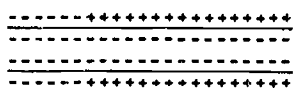
Students were able to answer some of the multiple choice questions on the structure and function of a neuron. Fifty-four percent (54%) were able to identify the movement of a nerve impulse through a neuron in question 84. However, students were unable to label the parts of a neuron in questions 120 to 124. Only 15% identified the cell body in item 120 and a mere 28.1% labelled correctly the synapse in question 124.

84. *Which diagram below best represents the movement of a nerve impulse through a neuron?*

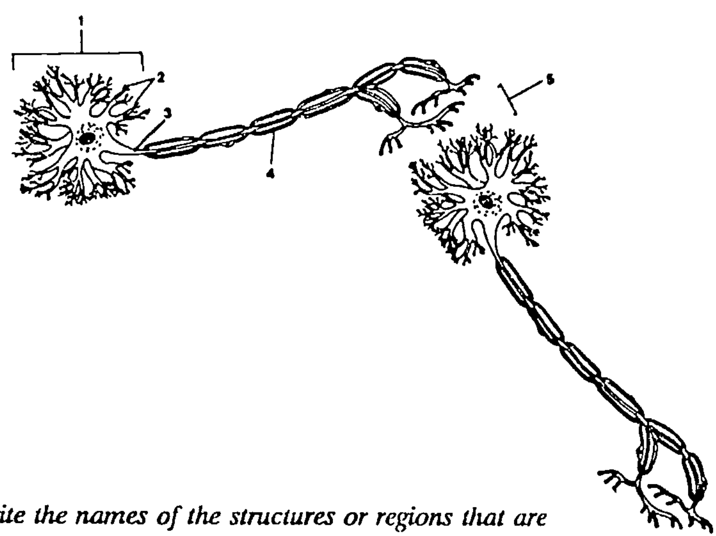
15.1% A) 

54.3 * B) 

15.6 C) 

14.1 D) 

Use the following diagram to answer questions 120-124.



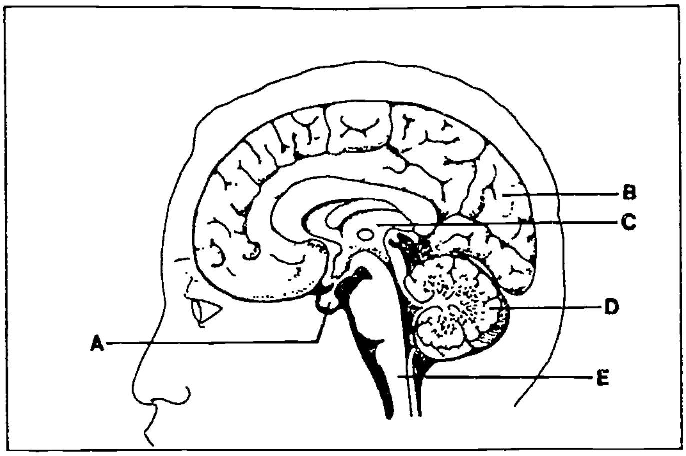
Write the names of the structures or regions that are indicated by the numbers in the diagram above.

120. *1:* cell body

124. *5:* synapse

Many students were unsuccessful in answering the questions dealing with the eye, ear and brain. Only 45.7% identified the cerebellum in question 86.

Use the following diagram to answer question 85 and 86.

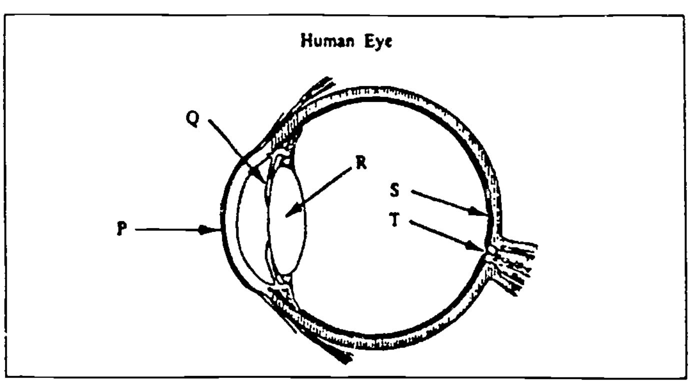


86. *Which part of the brain is the cerebellum?*

4.5%		A)	A
33.4		B)	B
12.4		C)	C
45.7	*	D)	D
3.5		E)	E

Thirty-four point three percent (34.3%) answered question 87 correctly.

Use the following diagram to answer question 87 and 88.

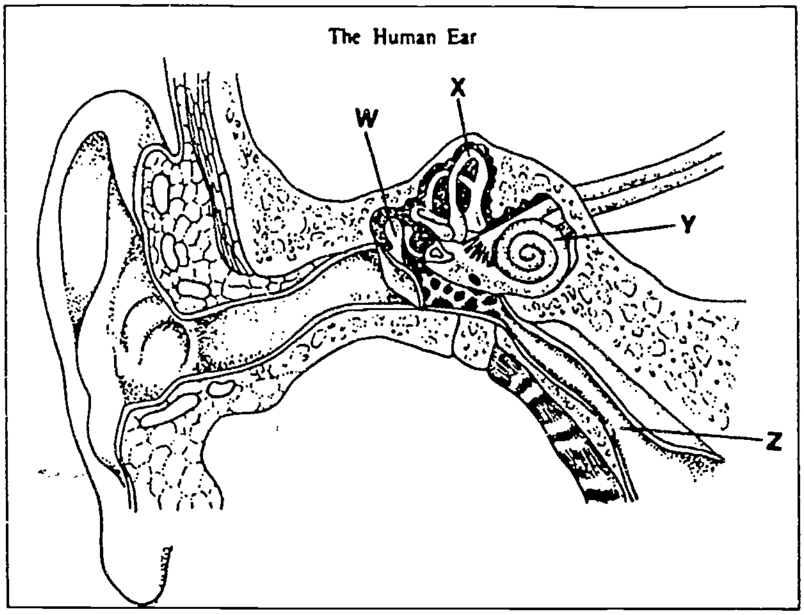


87. *What two structures respond to changes in light intensity?*

26.3%		A)	P and Q
30.8		B)	P and R
34.3	*	C)	Q and S
7.8		D)	S and T

Thirty-one point three percent (31.3%) answered question 89 correctly.

Use the following diagram to answer question 89 and 90.



89. *The sensory receptors for balance are found in the structure labelled*

21.2%		*A)*	*W.*
31.3	*	*B)*	*X.*
35.4		*C)*	*Y.*
9.3		*D)*	*Z.*

Endocrine System

The performance of students on this subtest was unsatisfactory. The mean percent of scores on this subtest was 46%. This is due in part to the fact that many teachers had not taught it. From those surveyed, 84.5% indicated that they teach this unit. Others teach topics like AIDS which they give higher priority.

Items 94 and 95 were answered satisfactorily. Fifty-one percent (51%) of the students answered item 94 correctly and 53.5% answered item 95 correctly.

94. Most hormones produced by the endocrine glands are initially released into the

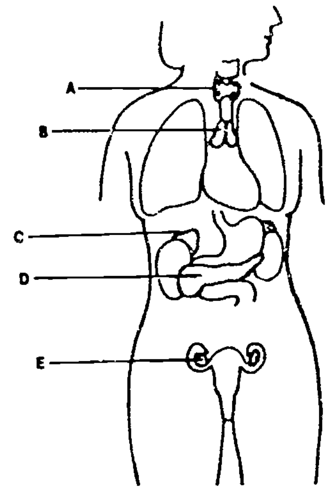
15.6%		*A)*	*lymph.*
51.0	*	*B)*	*blood.*
13.1		*C)*	*target cells.*
18.9		*D)*	*nervous system.*

95. The thickening of the lining of the uterus is in <u>direct</u> response to increased levels of

4.8%		*A)*	*oxytocin.*
53.5	*	*B)*	*estrogen.*
28.6		*C)*	*FSH.*
10.6		*D)*	*LH.*

Items 91 and 92 were poorly done. Forty point nine percent (40.9%) answered item 91 correctly and 40.9% answered item 92 correctly.

Use the following diagram to answer question 91 and 92.



91. *Which structure secretes a hormone that prepares a human to cope with a sudden emergency?*

13.7%	A)	A
21.5	B)	B
40.9	* C)	C
13.7	D)	D
8.9	E)	E

92. *The structure which secretes BOTH enzymes and hormones is*

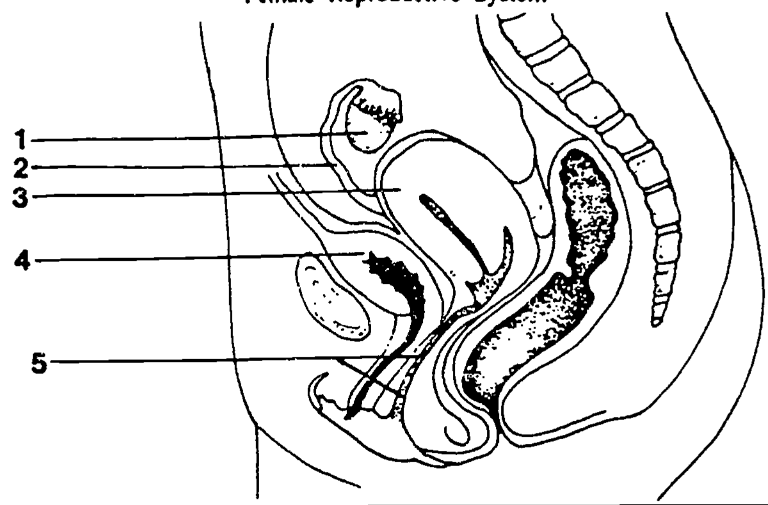
8.8%	A)	A
10.9	B)	B
17.5	C)	C
40.9	* D)	D
20.2	E)	E

Reproduction

The performance of students on this subtest was unsatisfactory. The mean percent of scores on this subtest was 39%. This was another unit that was taught by only 79.1% of the teachers surveyed. It was omitted by others due to the lack of time or lesser priority in terms of other topics like AIDS. Also, some teachers felt that it is covered at another level (Biology 300). Students' knowledge of basic structures was satisfactory but their knowledge of functions and mechanisms was unsatisfactory. For example, only 65.9% of the students were aware that the ovaries produce hormones in item 99.

Use the following diagram to answer question 99 - 102.

Female Reproductive System



99. *In a human female, hormones are produced by structure*

65.9%	*	A)	1.
3.6		B)	2.
20.5		C)	4.
7.8		D)	5.

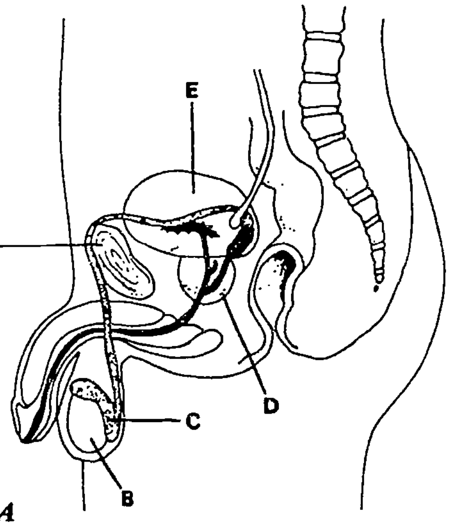
The source of menstrual flow in human females was not well known. Only 43.7% of the students answered item 101 correctly.

101. *The structure from which the menstrual flow originates is*

14.2%		A)	1.
43.7	*	B)	3.
20.2		C)	4.
19.5		D)	5.

Only 45.7% were able to identify the source of sex hormones in the human male.

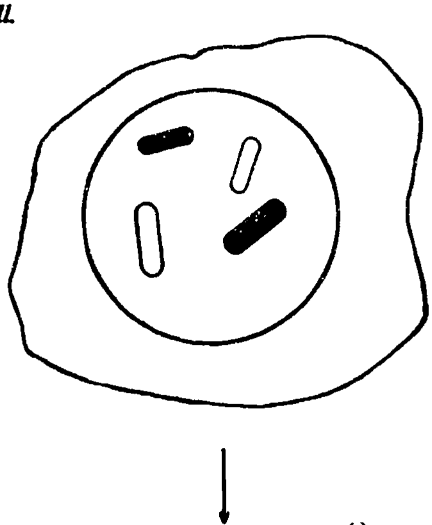
103. *In the diagram below, what is the structure that produces sex hormones?*



12.9%	*A)*	*A*
45.7	* *B)*	*B*
11.1	*C)*	*C*
17.1	*D)*	*D*
11.1	*E)*	*E*

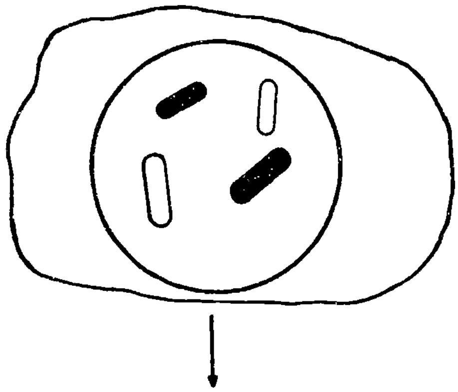
Many students confused mitosis with meiosis. Generally speaking, students understood mitosis better than meiosis. Sixty-three percent (63%) of students received full or partial credit for item 129.

129. *The diagram below represents a cell which is about to undergo mitosis and cytokinesis (cell division). Draw the correct number of cells that would be formed when division is complete. Also show the number of chromosomes in each cell.*



Forty-six percent (46%) of students received full or partial credit for item 132.

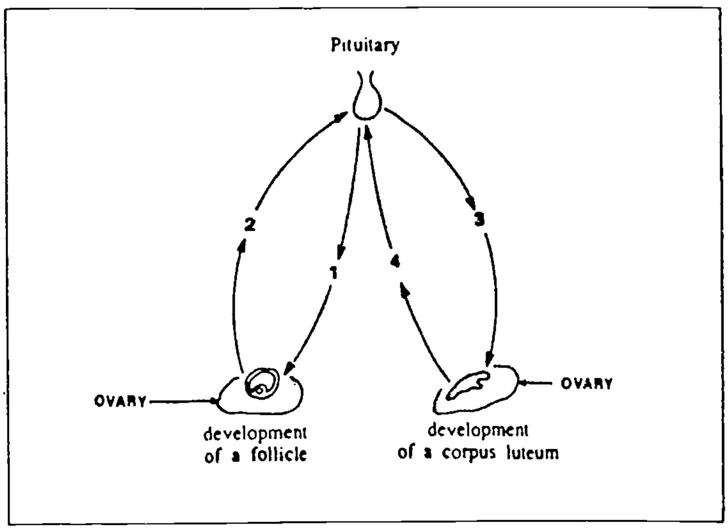
132. The diagram below represents a cell which is about to undergo meiosis. Draw the correct number of cells that would be formed when meiosis is complete. Also show the number of chromosomes in each cell.



Items 105 and 106 were the most poorly done of all the multiple choice questions. Twenty-two percent (22%) answered item 105 correctly and 11.8% answered item 106 correctly.

Use the following diagram to answer questions 105 and 106.

The relationship between the pituitary and the ovaries



105. The hormone represented by number 3 is

*22.0% **	*A)*	*LH.*
24.2	*B)*	*FSH.*
35.1	*C)*	*estrogen.*
16.2	*D)*	*progesterone.*

106. This diagram best illustrates the process of

41.2%	*A)*	*ovulation.*
8.1	*B)*	*circulation.*
16.4	*C)*	*gestation.*
17.2	*D)*	*menstruation.*
11.8	** E)*	*negative feedback.*

Homeostasis

The performance of students on this subtest was very unsatisfactory. The mean percent of scores on this subtest was 16%. The committee was surprised as this is the major theme running throughout the entire course.

Only 26.5% of students were able to define homeostasis in item 136. Thirty-five percent (35%) did not even attempt the question.

136. What is homeostasis?

The maintenance of a balanced (stable) environment within a living organism.

Item 137 was very poorly done. Only 2% of students received full marks for this item. Thirty-six percent (36%) had no knowledge of the question chosen and another 37% did not even attempt the question. Many students appear to have difficulty organizing their thoughts and writing them down on paper.

Answer only one of these items in the space provided below.

I. Describe how the circulatory system maintains homeostasis with respect to body temperature in the human body.

OR

II. Describe how the brain, heart, and lungs work together to maintain homeostasis with respect to carbon dioxide concentration in the human blood stream

OR

III. Describe how the hormones insulin and glucagon work together to maintain homeostasis in the bloodstream.

ITEM CHOSEN:__________ (Choose one of the three above.)

137. ____

____

General Conclusions

Generally, the results of the 1990 Biology 200 curriculum assessment test were somewhat disappointing. Even though the students did reasonably well on the multiple choice questions, their performance on the written response items was unsatisfactory. It was the opinion of the Technical Advisory Committee that this could be attributed to the following:

1. Students may not have taken the test seriously as it did not count towards their final mark.

2. Some students did not have the knowledge to answer the questions; others were unable to organize their thoughts and express them clearly on paper.

3. The items dealing with the last 3 units (nervous system, endocrine system, and reproduction and development) were more poorly done than the first six units. Several teachers (21%) indicated that they did not have enough time to teach these units. In many schools the unit on reproduction and development is deliberately taught in Biology 300 as an introduction to genetics.

4. Many students were able to describe single events that occur in a living organism but had difficulty linking ideas together and relating them to a general process like homeostasis.

5. Students experienced great difficulty in questions which entailed transfer of knowledge, even in the multiple-choice section of the test.

TEACHER SURVEY RESULTS

The Teacher Questionnaire provides Manitoba Education and Training with opinions from experienced educators in the field. This report summarizes the comments of the 129 out of 152 Biology 200 teachers who completed the Questionnaire. Here is a summary of the information collected in each of the nine areas surveyed.

I. TEACHER BACKGROUND

The academic background of Biology 200 teachers appears to be quite satisfactory. Most have taken several courses in biology and chemistry at the university level. (61.2% - 87.6%)

The majority of Biology 200 teachers are very experienced in teaching this course. Sixty-five point nine percent (65.9%) have taught Biology 200 for more than seven years. Ten percent (10%) of the teachers have taught the program for one year.

The majority of Biology 200 teachers (75.2%) have not taken any university science-related courses within the last five years. However, 45.7% have attended workshops and another 31% have attended seminars related to the Biology 200 program.

II. SCHOOL ORGANIZATION

Twenty-three out of 150 schools surveyed were teaching combined Biology 200-201 classes.

The average class size for Biology 200 was 24 students.

Teachers indicated that they spend 10 hours per cycle preparing lessons and laboratory activities as well as marking student work for each Biology 200 class they teach.

III. SCHOOL FACILITIES

Most teachers (83%) teach this course in a science laboratory or a combined classroom/laboratory. Only 13.2% conduct their classes in a regular classroom.

The majority of teachers (78.3%) indicated that they have access to a laboratory for 60% or more of their class time.

Physical facilities found to be most lacking were as follows:

a) ventilation - Inadequate or very inadequate (41.1%)
b) locked metal storage cabinet for volatiles - (36.5%)
c) cold storage/refrigerator - (31%)
d) preparation rooms - (26.3%)
e) separate storage cabinet for chemicals - (23.6%).

Most high school biology laboratories have fire extinguishers, safety goggles, fire blankets, eye wash stations, and master gas shutoff valves. The safety equipment that is least available is as follows:

a) light indicator for gas shutoff
b) deluge shower
c) main power switch/GFI
d) cabinet (safety goggles).

The majority of schools (72.9%) do not have laboratory assistants. Twenty-one point seven percent (21.7%) of schools have paid adult assistants and 3.9% have paid student assistants.

Most teachers (77.5%) indicated that their laboratory equipment is adequate. Examples of equipment that was lacking in the remaining schools are listed below:

a) autoclave
b) compound microscopes
c) pH meter
d) stereo dissecting microscopes
e) computers
f) physiology sensors (computer driven)
g) electronic balances
h) dissection equipment
i) glassware
j) electrophoresis apparatus
k) stethoscope
l) sphygmomanometer

Supplies were rated adequate by the majority (86%) of teachers. Eight teachers indicated that their supply budgets were inadequate.

IV. CURRICULUM GUIDE

Almost all teachers (98.4%) are using the Manitoba Curriculum Guide. Sixty-three point six percent (63.6%) are using it to a great extent; 31% are using it to a moderate extent.

The majority of teachers endorse the objectives, content, suggested activities, and recommended textbooks for this course. However, some teachers (11%-16%) expressed their dissatisfaction with the suggested activities, sources of laboratory activities, and recommended texts.

Most of the core units are being taught. Those units that are most often omitted are:

a) Reproduction and Development
b) Endocrine System
c) Nervous System
d) Excretory System.

The reasons cited to account for the omission of these units are as follows:

a) Time constraints
b) Unit taught in another grade/course, e.g., Biology 300
c) Other options or extensions are being taught, e.g., AIDS
d) Classes lost due to other school activities, e.g., band program.

The options most frequently taught are Heart Health and Sexually Transmitted Diseases. The options least frequently taught are Aging Human Behaviour and Basic Ecology.

V. TEACHING RESOURCES AND MATERIALS

The most widely used textbooks are:

Biology. Kormondy, E. J., and Essenfeld, B.E., Addison-Wesley, 1984 and

Biology of Ourselves. Berry, G. and Gopaul, H., John Wiley and Sons, 1982.

The majority of teachers (79.5%) are satisfied with the principal text they are currently using.

VI. TEACHING ACTIVITIES AND METHODOLOGY

Most teachers are utilizing a group-centered approach with some individualization in their implementation of the Biology 200 program.

Teacher lecture is the most common activity occurring in Biology 200 classrooms followed by student-performed laboratories.

Students tend to perform laboratory activities once per cycle. They spend the majority of their time listening to teachers' lectures and taking notes. They also spend a considerable amount of time answering questions from textbooks. They rarely design and conduct their own experiments. They occasionally do library research and apply information to new problem situations.

VII. EVALUATION

Biology 200 students are evaluated primarily by teacher made tests which include multiple choice, true-false, matching, recall, and application questions. Some emphasis is also placed on homework assignments, laboratory reports, and individual projects or research papers.

Almost all (96.9%) Biology 200 teachers indicate that their students write final exams. Approximately half of the teachers indicated that exemptions from final exams are available to their students.

The majority of teachers (71.3%) mark all the laboratory reports that are submitted by their students.

VIII. STUDENT EXTRACURRICULAR ACTIVITIES IN BIOLOGY

The main Biology-related activity available to students outside of Biology classes is the Science Fair.

Many teachers do not take their classes on field trips due to insufficient time, too much effort required, as well as complaints from other teachers. Some of the field trips that are conducted include:

a) Delta Field Station
b) Fort Whyte Nature Centre
c) Red Cross Laboratory
d) Freshwater Fisheries Laboratory
e) ABI Biotech Institute.

IX. FUTURE DIRECTIONS

At least 30% of teachers wish to have specific inservice sessions on the Core and Option topics in the Biology 200 program. Many teachers (58%) wish to have professional development activities focus on innovative teaching strategies, for example, cooperative learning. Fifty percent (50%) indicate that micro computers should be utilized in the Biology 200 classroom. A sizeable number (79%) of teachers wish to have continued updates on the newest developments in Biology and exposure to new laboratory activities that augment the Biology 200 instruction. A fair number of teachers (22-34%) wish for inservices that deal with assessment techniques and adaptation of the curriculum.

Recommendations

The recommendations that follow are based on the results of the Biology 200 Assessment and the insights of teachers on the Technical Advisory Committee. These recommendations have implications for specific target groups or their implementation may entail overlapping responsibilities with other groups. The letter(s) at the end of each recommendation indicates the group(s) to which it is principally directed. This legend provides the letter symbol for each target group(s):

Manitoba Education and Training	**= M**
Teachers	**= T**
School Divisions and Administrators	**= S**
Faculties of Education	**= F**

It appears that the Biology 200 course has too much content to be covered in the allotted time. Twenty-one percent (21%) of the teachers surveyed indicated that they are unable to complete the course due to shortage of time. Twenty-one percent (21%) omit Reproduction and Development since they believe it is covered in Biology 300; 15% omit the Endocrine System in preference for other topics such as AIDS; and 12% leave the Nervous System for the end and find that they have run out of time. Therefore, it is recommended that:

1. **the Biology 200 curriculum be restructured so that Reproduction and Development would be integrated into the Biology 300 program. (M)**

From the student results, it has been observed that students encountered difficulty with questions requiring transfer of information, specific details with technical information and the use of diagrams and illustrations. Therefore, it is recommended that:

2. **teachers examine the approaches used in teaching the Biology 200 course with greater focus on problem solving and critical thinking. (M, T)**

The Teacher Survey reveals that over 90% of teachers engage their students in laboratory activities less than 40% of their instructional time. Insufficient preparation time has been cited as a reason for de-emphasizing laboratory activities. A large group of teachers (78.3%) would like a list of new and meaningful laboratory activities which would interest and challenge students. Perhaps, to provide concrete experiences for students which would enable better transfer of knowledge, it is recommended that:

3. a laboratory supplement that contains meaningful activities for students be provided for classroom teachers. (M, T)

According to the Teacher Survey, 43.4% of teachers indicated that they have not attended a Biology workshop, and 45% have not attended a Biology seminar within the last five years. Also, when asked about preferred workshops, 29.5% want content background in the Core topics; 33.3% want content background in the Optional topics; 58.1% want innovative teaching strategies; 34.1% want methods for adapting the curriculum; 79.8% wish to have update on the newest development in Biology; 78.3% need new laboratory activities to augment the Biology 200 program; 49.6% need to learn how to use the microcomputer in the Biology classroom; and 57.4% need update on technological applications (e.g., recombinant DNA, biotechnology, pharmaceutical). Based on these obvious needs expressed by teachers, it is recommended that:

4. a series of workshops which would benefit all Biology teachers throughout the province be offered. (M,S,F) The following topics have been suggested:
   - update on the newest developments in biology
   - new laboratory activities to augment the Biology 200 program
   - innovative teaching strategies
   - technological applications
   - use of microcomputers in the biology classroom.

In view of the fact that 22.5% of the teachers surveyed would like inservicing on assessment techniques and roughly 45% of these teachers have not attended Biology-related workshops lately, it may be necessary to ensure that assessment techniques are covered in other training sessions. Most teachers (97%) indicated that their students write final examinations. Therefore, it is recommended that:

5. the Faculties of Education ensure that their teachers are familiar with a variety of test development techniques. (F)

6. School divisions and Manitoba Education and Training provide inservice opportunities for teachers to refresh their student assessment and evaluation skills. (M, S)

Given the fact that a large number of students did not attempt the written-response questions and that performance was weak for those who did complete them, the Biology 200 TAC felt that students need to be given specific training in writing short and long answers on an ongoing basis. Undoubtedly, this course requires a fair amount of reading and writing. Therefore, it is recommended that:

7. school counsellors make students aware of the reading and writing skills required for Biology 200. (T)

8. teachers provide students with regular practice and feedback on written-response exercises. (T)

9. teachers provide students with opportunities to answer higher-level application and problem-solving questions on tests. (T)

The teachers surveyed indicated that they spend on average 10 hours per six-day cycle in preparing Biology lessons and laboratory activities and the marking of laboratory reports. But, their time-table provides only 4.5 hours preparation time per cycle. Seventy-one point three percent (71.3%) of the teachers say that they mark all laboratory reports for every student. However, over 90% of these teachers indicated that their students are engaged in laboratory activities less than 40% of their instructional time. The de-emphasis on laboratory activities could be a result of insufficient preparation time. Therefore, it is recommended that:

10. laboratory assistants be made available to assist teachers in providing students with high quality laboratory programs. (S)

Based on the overall results (student and Teacher Survey) and the insights of the TAC members, the Committee suggests that teachers:

11. place greater emphasis on the concept of homeostasis as it applies to the various organ systems of the human body.

12. provide students with practice in linking ideas together and relating them to a general process like homeostasis.

13. keep up-to-date by enrolling in workshops, seminars, and university courses.

CHAPTER 5

Physics 300

DISCUSSION OF RESULTS

The test comprised only Core topics. It was the opinion of the Technical Advisory Committee that testing of Option units should be waived because there are 9 Option units and each teacher has the freedom of unit selection.

The Core contains six units. For each unit there were two types of questions: multiple choice questions and long, written response questions.

Table 3 provides a summary of test results.

Table 3

MEAN PERFORMANCE ON SUBTESTS

SUBTEST		TOTAL POSSIBLE MARKS PER SUBTEST	MEAN RAW SCORE	MEAN PERCENT	STANDARD DEVIATION RAW SCORE
1. WAVES	(MULTIPLE-CHOICE)	10	6.60	65.97	2.17
WAVES	(WRITTEN-RESPONSE)	14	6.10	43.55	3.86
WAVES	(TOTAL)	24	12.69	52.89	5.20
2. STATIC ELECTRICITY	(MULTIPLE-CHOICE)	6	4.25	70.88	1.40
STATIC ELECTRICITY	(WRITTEN-RESPONSE)	4	0.63	15.81	1.22
STATIC ELECTRICITY	(TOTAL)	10	4.88	48.85	2.05
3. FIELDS AND FORCES	(MULTIPLE CHOICE)	8	3.74	46.76	1.92
FIELDS AND FORCES	(WRITTEN-RESPONSE)	3	1.45	48.37	1.08
FIELDS AND FORCES	(TOTAL)	11	5.19	47.20	2.52
4. BASIC ELECTRICAL CIRCUITS	(MULTIPLE-CHOICE)	12	6.58	54.81	2.66
BASIC ELECTRICAL CIRCUITS	(WRITTEN-RESPONSE)	8	4.28	53.54	2.16
BASIC ELECTRICAL CIRCUITS	(TOTAL)	20	10.86	54.30	4.28
5. BASIC MAGNETISM	(MULTIPLE-CHOICE)	5	2.52	50.47	1.35
BASIC MAGNETISM	(WRITTEN-RESPONSE)	10	4.02	40.20	3.36
BASIC MAGNETISM	(TOTAL)	15	6.54	43.63	4.06
6. ELECTROMAGNETIC	(MULTIPLE-CHOICE)	4	1.51	37.70	1.06
ELECTROMAGNETIC	(WRITTEN-RESPONSE)	5	2.05	41.00	1.50
ELECTROMAGNETIC INDUCTION	(TOTAL)	9	3.56	39.53	2.08

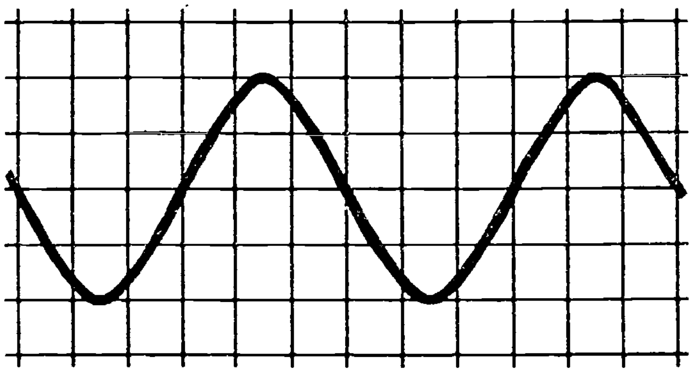
Number of students writing = 448

1. WAVES

The multiple choice questions on waves were answered well. The average score was 66%. Question 5 was the one question that had a low performance score of 45.3%.

USE THE STATEMENT AND DIAGRAM BELOW TO ANSWER QUESTIONS 4-6.

A wave generator dips into the water seven times every second. Each square is one centimetre on the side.



5. *What is the amplitude of this wave?*

45.3%	* *A.*	*2 cm*
4.2	*B.*	*3 cm*
46.4	*C.*	*4 cm*
3.5	*D.*	*6 cm*

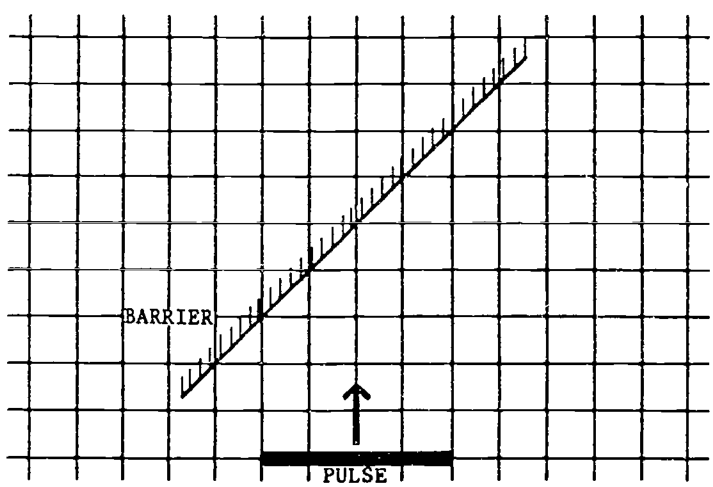
Students selected the distance between the trough and crest as amplitude. Amplitude and the wavelength were often interchanged by the students. Perhaps, the difference between these two concepts must be stressed more strongly so that students can distinguish between amplitude and wavelength.

Students did not do well in the written response questions on waves which had a mean score of 44%. In item 51, forty-seven percent (47%) of the students could draw the reflected pulse, but only 23% knew its direction.

PLACE YOUR ANSWERS IN THE SPACES PROVIDED FOR ITEMS 51-79. WHERE APPROPRIATE, SHOW FORMULAE, NUMERICAL SUBSTITUTIONS AND CALCULATIONS, AND UNITS ON THE ANSWERS. MARKS AWARDED FOR ITEMS ARE INDICATED IN PARENTHESES.

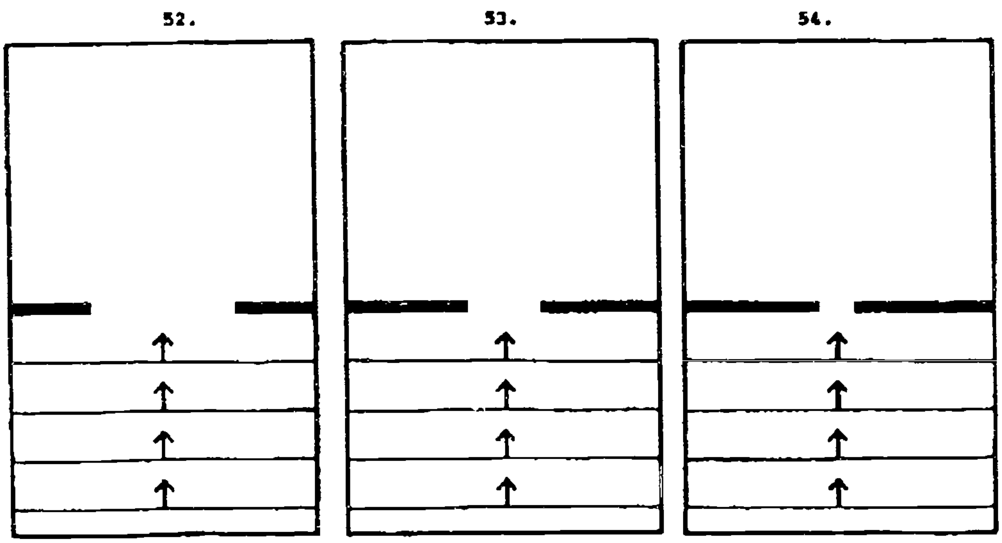
51. *In the diagram below, a straight 4 cm pulse moves towards a straight barrier at a speed of 6 cm/s. Draw the position and indicate the direction of the pulse one second later. (Each square is one centimetre on the side.)*

(2)

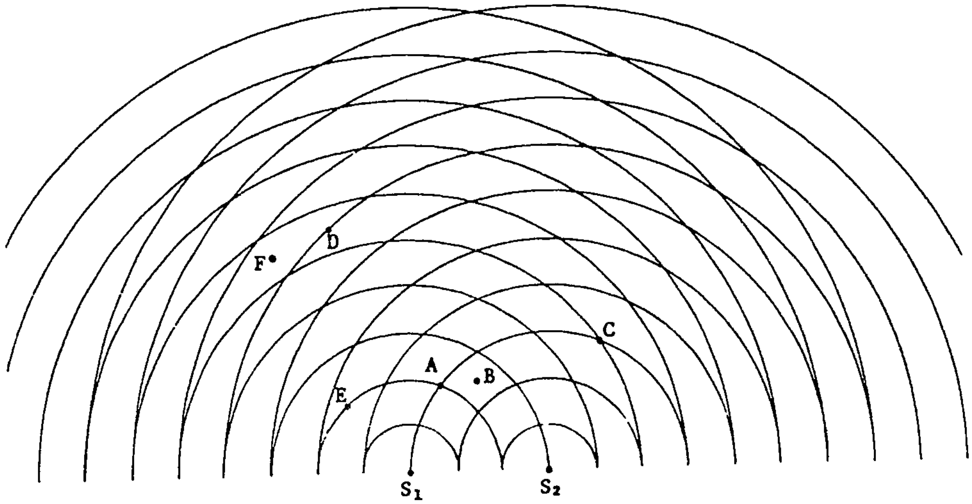


The diffraction of water waves passing through slits was done reasonably well. The diffraction pattern of water waves of different wavelengths passing through a slit of the same width was not done well. This particular difficulty was noted in questions 52, 53, and 54.

Sketch the shape of the waves in the diagrams below after they pass through the opening in each barrier.



Questions 58 and 61 requiring students to draw nodal lines on an interference pattern had a mean score of 25%. Many students did not attempt to draw nodal lines which may indicate that it was not part of their learning experience.



58. Draw all nodal lines on the diagram.

Indicate all letters which represent points that are:

61. on the nodal lines ________________

The topic of water waves interference was familiar to the students. Many were able to identify the positions of double crests and double troughs (60%). Only a few could identify the positions of the nodes (37%).

With the exception of the nodal lines, the performance on this unit was satisfactory.

2. STATIC ELECTRICITY

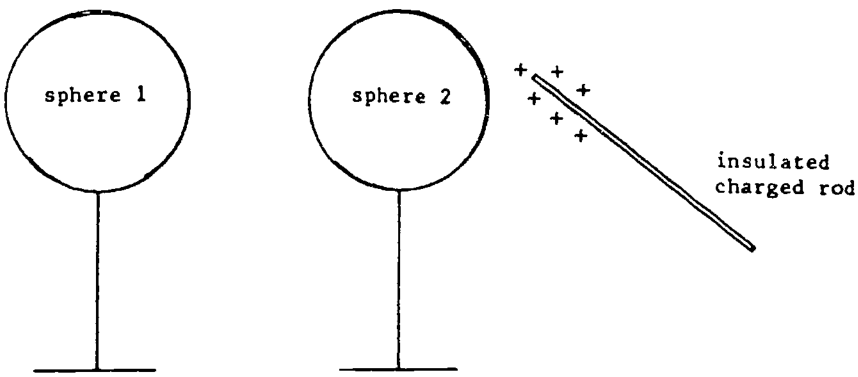
In general, the understanding of the molecular structure of metals and non-metals was poor. Students did not seem to understand that the electrons move freely in metals.

Students seem to have a good general knowledge of static electricity. The written response question 62 which required in-depth knowledge was done very poorly. The mean score was 16%. Charging of two objects with unlike charges and equal quantity is not an easy proposition at the best of times. It seemed that students

understood the question but the four-step solution stumped many. It appeared that in question 62 students were unable to apply learned concepts to a novel situation.

62. *You have an insulated metal rod carrying a large positive charge and two identical neutral metal spheres on insulated stands as in the diagram below.*

INSULATED METAL SPHERES



Describe the steps necessary to charge the spheres with an equal number of opposite charges. The charges are to be uniformly distributed over the spheres.

3. FIELDS AND FORCES

The performance of students was consistent on both the multiple choice and the written response items. The mean scores were 47% and 48% respectively. The questions requiring a straightforward application of Coulomb's Law had a mean score of 56%. Calculations which required the use of inverse square law and proportions had a mean score of 37% and obviously gave students some difficulty. See item 19.

USE THIS INFORMATION TO ANSWER QUESTIONS 19 AND 20.

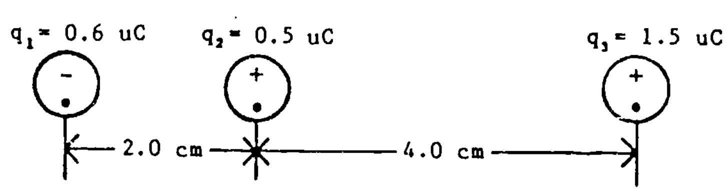
The force of electrostatic repulsion between two small charged spheres A and B is 7.2×10^{-5} N, when the separation distance between A and B is 0.12 m.

19. What is the force of repulsion if the distance between A and B is changed to 0.36 m?

37.0%	* *A.*	*8.0×10^{-6} N*
27.5	*B.*	*2.4×10^{-5} N*
28.3	*C.*	*2.2×10^{-4} N*
6.5	*D.*	*6.5×10^{-4} N*

It would appear that students knew the shapes of the electrical fields but not their directions. Question 63 provides an example of a complex problem which presented difficulty for students. A large number of students failed to realize that there is a point between two like charges where the electric field is zero, and that this point is closer to the smaller charge.

63. Three identical point charges are located as shown on the diagram below.



What is the net electric force exerted on q_2?

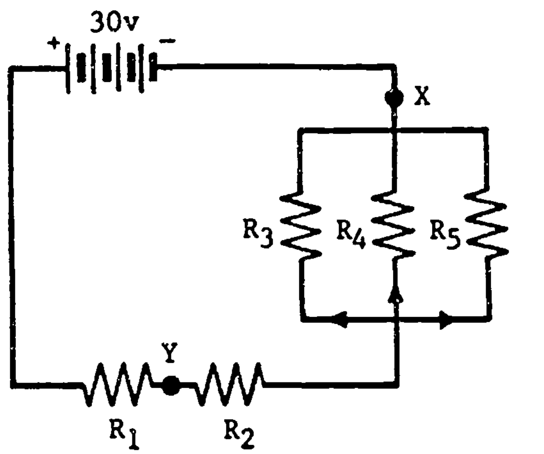
4. BASIC ELECTRICAL CIRCUITS

The basic electrical circuits unit was done adequately. There was consistency in response to both types of questions: the multiple choice and written response questions. The mean scores were 55% and 54% respectively.

The basic knowledge of the circuits was good. Questions on simple circuits (series and parallel) were answered correctly by most of the students. The questions about the current and potential difference in individual branches of a combined circuit proved to be difficult for many students. In questions 68 and 69 the measurement of the electric potential and the current in individual branches was not done well.

USE THIS INFORMATION AND DIAGRAM TO ANSWER ITEMS 64-71.

An EMF of 30 V with a negligible internal resistance is connected to two resistors in series and three resistors in parallel.



R_1 = 1Ω
R_2 = 7Ω
R_3 = 4Ω
R_4 = 6Ω
R_5 = 12Ω

68. *Calculate the potential difference across R_3.*

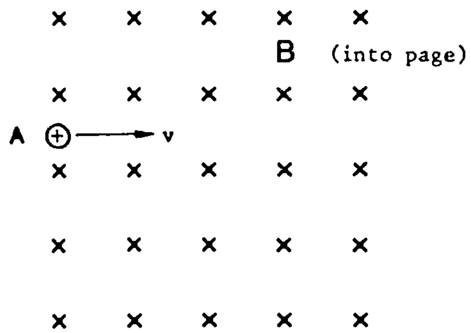
69. *Calculate the current passing through R_5.*

5. BASIC MAGNETISM

Students understood the directions of magnetic fields around a magnet, around a current carrying conductor and the magnetic fields around permanent magnets. The mean performance of students on this section was 50%.

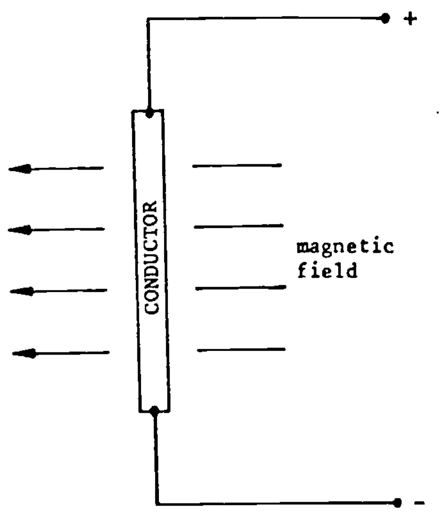
Items which involved calculations presented difficulty for students. The mean score was 40%. Questions 73 and 74 are examples of the type of questions with which students encountered difficulty in this subtest. Upon reflection, the Technical Advisory Committee realized that item 75 should have been included in the subtest Electromagnetic Induction and Alternating Current. Since it appeared in this subtest in the assessment and in the presentation of results in the *Preliminary Report*, it has been included in this subtest for this *Final Report* as well for purposes of consistency across reports.

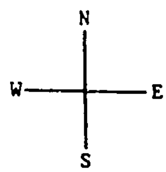
73. *A uniform magnetic field B of magnitude 0.25 T is represented by field lines pointing into the page, as indicated by the X's in the diagram below.*



A positive ion with a charge of 3.2×10^{-19} C enters this magnetic field at A moving to the right with a horizontal velocity of 4.0×10^{6} m/s. What is the <u>*magnitude*</u> *and* <u>*direction*</u> *of the instantaneous force exerted on the ion at point A?*

74. *A 30 A current flows through a conductor placed in a magnetic field of 0.8 T. Directions are indicated on the diagram below. What is the* <u>*magnitude*</u> *and* <u>*direction*</u> *of the force exerted on a 10 cm conductor?*





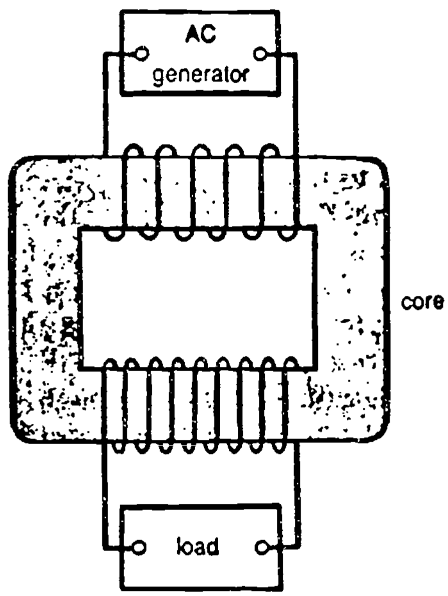
75. *A coil of 100 turns is pulled in 0.020 s from a place where the magnetic flux is 3.1 x 10^{-4} Wb to a place where the magnetic flux is 1.0 x 10^{5} Wb. Find the average EMF induced in the coil.*

6. ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

The questions on electromagnetic induction and alternating current were fewer than the Curriculum Guide might suggest. However, it was felt that few schools would have time to study this unit at the time of the assessment. Four basic questions on this unit proved to be difficult for the students. The mean score was 37% which was lower than the scores for other units.. The basic question on the transformer was answered by only 50% of the students. There was some concern by the Committee that more than half the students did not attempt item 79.

USE THE DIAGRAM BELOW TO ANSWER ITEMS 76-79.

SIMPLE TRANSFORMER



79. *Why is an AC generator used in the transformer?*

General Conclusions

a) Students were able to do straight-forward applications of formulae but had difficulty where transfer of knowledge and interpretations were required.

b) All multiple choice questions were answered by the students, but the written-response items were not attempted in many instances. However, there were satisfactory responses by those who completed the written-response questions. Actually, the mean score for the multiple choice items and written-response items was almost the same in the Electrical Circuits subtest. Also, in the Fields and Forces and Electromagnetic subtests the mean scores were higher for the written-response items than multiple-choice items.

TEACHER SURVEY RESULTS

The Teacher questionnaire provides Manitoba Education and Training with opinions from teachers about various aspects of teaching and learning Physics in Manitoba. These opinions could be utilized by the Department in future planning of Physics courses and selecting of textbooks or laboratory materials. It serves as a basis for making better interpretation of student results.

This Report summarizes the comments of the 114 out of 118 teachers of Physics 300 who completed the Questionnaire. In almost every instance teachers left some questions unanswered, but for purposes of this Report, the number of responses was converted to a percentage for any particular item based on the number of questionnaires returned. The following is a summary of the information collected in the nine areas surveyed:

I. TEACHER BACKGROUND

Eighty-four point five percent (84.5%) of Physics teachers in Manitoba have taken at least two courses of Physics at university level. Ninety-six percent (96%) of them took at least one course of Mathematics. About half of the teachers have at least one credit in Computer Science. Ninety percent (90%) have credit in Chemistry, while 50% have credits in Earth Sciences.

Besides teaching Physics, 34.5% taught Chemistry, 35% Junior High Science and 56% Mathematics.

Sixty-six percent (66%) of the respondents have taught Physics more than seven years. Even though few of them indicated that they have taken Science courses at university in the last five years, 50% indicated that they attended seminars and another 43% attended workshops. Most of the teachers (77%) belong to the Science Teachers Association of Manitoba (STAM).

II. SCHOOL ORGANIZATION

Half of the respondents teach in a semester system and the rest in a full-year system. Only 6% teach combined grades. On the average, teachers spend 15 hours per cycle in preparation and marking papers while the teacher's timetable provides 3.75 hours per cycle for preparation.

III. SCHOOL FACILITIES

Eighty-four percent (84%) of teachers teach Physics in laboratory or combined classroom and laboratory. Eighty percent (80%) of the teachers have lab facilities available more than 60% of the time. A majority of the teachers were satisfied with their facilities.

Thirty-two percent (32%) indicated that they have inadequate preparation rooms; 15% inadequate materials and student work storage space; 12% have inadequate electrical outlets; and 16% have inadequate water outlets.

The majority of laboratory rooms (72-90%) contain an eye wash station, goggles, fire extinguishers, fire blankets, and master gas shutoff. Fifty-nine percent (59%) have a first aid kit and over 20% have a main power switch and light indicator shutoff.

Only 16% have paid lab assistants and 73% indicated satisfaction with their lab equipment.

Many teachers indicated that they operate on a limited budget and that their laboratories lack equipment for circuits and magnetism among others. The equipment needs repair and upgrading. Also, the teachers would like to use computers in their Physics 300 programs.

IV. CURRICULUM GUIDE

Ninety-nine percent (99%) of teachers use the curriculum guide and 96% base their program on the objectives in the guide. In the opinion of 80% of teachers the curriculum is appropriate for the students.

Twelve percent (12%) of teachers thought that the textual material for instruction is not appropriate for the students and 10% are not satisfied with the textual material for laboratory activities.

Many teachers indicated that units on Basic Magnetism and Electromagnetic Induction and Alternating Current are not taught in sufficient depth.

Several teachers teach Momentum and Energy units in Physics 300 and shorten or omit the units referred to above.

All options listed in the curriculum guide are taught by different teachers. The time spent on teaching options varies between 1 hour and 13 hours.

Eighteen percent (18%) of teachers do not teach any options due to the lack of time.

V. TEACHING RESOURCES AND MATERIALS

The majority of teachers (61%) indicated that their main textbook is: *Modern Physics* by Williams, J. et al, Holt Canada. Two other texts that were used by 14% and 12% of teachers respectively were: *Fundamentals of Physics: A Senior Course* by Martindale, et al, Heath Canada, and *PSSC Physics* by Haber-Schaim, U. et al, Heath, Canada. Six percent (6%) of the teachers indicated that they did not use a textbook.

Sixty-seven percent (67%) of the teachers were satisfied with the texts that they use while 28% were dissatisfied with their textbooks.

VI. TEACHING METHODOLOGY

All teachers include the following in their teaching methods to different degrees: lecture, laboratory demonstrations, laboratory performance, individualized instruction, and problem-solving.

VII. EVALUATION

Most of the teachers (83%) evaluate students' performance on the teacher-made tests which include multi-step numerical problems and laboratory reports.

Ninety-eight percent (98%) of teachers indicated that their students write final exams and 26% allow exemptions.

Seventy-four percent (74%) of teachers indicated that they mark each student's laboratory report.

VIII. STUDENT CO-CURRICULAR ACTIVITIES

Forty-five percent (45%) of teachers do not provide any opportunities for the students to participate in Physics-related activities and 31% of the teachers provide opportunities for their participation in Physics contests. Six percent (6%) of the teachers give students an opportunity to participate in astronomy clubs and 16% allow participation in photography clubs.

During class periods some students are allowed to work on science projects, science essays, and student-initiated projects.

Co-curricular activities include visits to:

a) Whiteshell Nuclear Research Station in Pinawa
b) University of Manitoba Engineering workshop held in February
c) Planetarium in Winnipeg
d) Science Symposium in Brandon
e) REPAP forestry, pulp and paper mill
f) Brandon University Observatory
g) University of Manitoba Cyclotron
h) Local industry (Pioneer Electric, Canada Wire)
i) Science Fair
j) Children's Hospital (Biomechanics Laboratory)
k) Museum of Man and Nature
l) Bristol Aero Plant
m) Seven Sisters Generating Station

IX. FUTURE DIRECTION

To improve their teaching and prepare students for the 21st century, the teachers recommended that:

a) they have a text which is suitable for the core topics; (8%)
b) a laboratory guide with complete instructions for teachers and students be provided; (11%)
c) computers be incorporated in Physics instruction; (13%)
d) alternate energy topics be included in Physics programs; and (14%)
e) electronics be included in the core topics. (28%)

Recommendations

The recommendations that follow are based on the results of the Physics/Physique 300 assessment and the insights of teachers on the Technical Advisory Committee. These recommendations have implications for specific target groups or their implementation may entail overlapping responsibilities with other groups. The letter(s) at the end of each recommendation indicates the group(s) to which each is principally directed. This legend provides the letter symbol for each target group:

Manitoba Education and Training	**= M**
Teachers	**= T**
School Divisions and Administrators	**= S**
Faculties of Education	**= F**

Based on the feedback received on the Teacher Survey, 28% of teachers would like some change in the Physics/Physique 300 curriculum. Generally, teachers want a course with embellished Core topics rather than Option topics. They would like a more practical course that is challenging to a student who is contemplating further study in Science. The Technical Advisory Committee feels that some topics fit better in Physics/Physique 200 than Physics/Physique 300 and vice versa. Thus, it is recommended that:

1. **the units taught in Physics/Physique 200 and 300 be restructured, particularly, shifting Waves from the 300 program to the 200 program, and placing Energy in the 300 program. It appears that the Physics/Physique 200 course has a heavy emphasis on mathematics and Waves fits well. Energy can be used as a review of the Physics/Physique 200 course and blends well with other topics in Physics/Physique 300. (M)**

2. **the curriculum guide be reviewed in an effort to provide greater clarification of content (e.g., unit on Waves) and consider the possibility of placing greater emphasis on Electronics in Physics/Physique 300. (M)**

More than ten percent (10%) of the teachers surveyed wish to have better material resources for teaching Phy ics/Physique 300. Some would like to have textbooks that have more extensive coverage of the various Core and Optional topics. Others wish to have a textbook that is more closely tied to the prescribed curriculum. Thus, it is recommended that:

3. **the recommended textbooks of Physics/Physique 300, along with other available texts, be reviewed to determine the one(s) that cover all the Core topics and some or all of the Options. (M)**

When asked about preferences for inservice or professional development, the results reveal that: 45% of Physics/Physique 300 teachers would like inservicing in content background for the Core topics; 43% in the content background for the Optional topics; 45% would like inservicing on innovative teaching strategies; 30% on methods for adapting the curriculum; 61% on the update on the newest developments in Physics; 62% on the use of microcomputers in the Physics classroom; 67% on technological applications (e.g., super conductivity, nuclear advances); and 76% on new lab activities to augment the Physics/Physique 300 program. Based on this variety of professional development needs, it is recommended that:

4. **professional development opportunities for teachers to upgrade their skills and knowledge and refresh their methodologies for teaching high school Physics courses be provided. (M,S,F)**

5. **opportunities for Physics/Physique 300 teachers to share with colleagues ideas and concerns and ways of overcoming these be provided. (S)**

Almost 45% of the teachers surveyed indicate that their students are not involved in Physics-related co-curricular activities. Yet, at least 8% would like to have a more practical course. Therefore, it is recommended that:

6. **teachers endeavour to have students involved in Physics-related co-curriculur activities, thereby enhancing the practical aspect of the course(s). (T)**

7. **teachers provide students with a Physics/Physique 300 program that has sufficient blend with theory and its application. Let learning be related to everyday life as much as possible. (T)**

CHAPTER 6

Chemistry 200/300

DISCUSSION OF RESULTS

The Science Assessment Program 1990 included a comparison component in Chemistry 200 and 300. The objective of this component was to determine any change which might have occurred in student achievement in Chemistry 200/300 from the time of the 1981 Provincial Chemistry 200/300 Assessment to the occasion of the 1990 Assessment. Indirectly, the results of this comparison test should reflect on any change which may have occurred in the quality of instruction in Chemistry during the comparison period or in course content/emphasis brought about by the curriculum revision which was introduced in 1984.

The 1990 Assessment was designed to be written in one hour as opposed to a 2-hour Assessment that was conducted in 1981. Since there were changes to the Chemistry 200 and 300 curricula from the 1981 Assessment to the occasion of the 1990 Assessment, unmatched items were deleted from both tests (Chemistry 200 and 300) so that they reflected the current curricula. Only items common to both assessment years were utilized. Organic Chemistry was a new subtest added to the 1990 edition of the Chemistry 200 test. The tests were administered in June, 1990 to coincide with the time the testing occurred in 1981.

STUDENT RESULTS

Chemistry 200

The student results of 1981 were based on a sample of 516 out of a total of 3028 students enrolled in Chemistry 200. This represented 17% of the total population and 85% of the designated sample (606 students). In 1990, from the 28 schools randomly selected and 984 possible students, 862 students returned a completed Chemistry 200 Assessment for a completion rate of 87.6%. Table 4.1 provides a comparison of the mean performance of students for 1981 and 1990.

Table 4.1

Mean Performance for 1981 and 1990

	Core Units	1981		1990	
		No. of Items	Average Percent Correct	No. of Items	Average Percent Correct
A	Introduction to Periodic Table and Elements	17	57	17	55
B	Concepts of Matter	14	60	14	51
C	Organic Chemistry	*		10	42
D	Gases	11	51	11	49
E	Solutions	11	54	11	46
	Safety	7	66	7	62

* **There were no items for the Organic Chemistry unit in 1981 and there is no comparison in this unit. A descriptive report on the 1990 Organic Chemistry results occurs on page 82.**

Unit A Introduction to Periodic Table and Elements (17 items)
1981 items: 1, 4-7, 55-61, 64, 67-70
1990 items: 1-5, 39-45, 48-52

Students in 1990 scored better on all items involving the naming of compounds or in the writing of formulas. Students in 1981 scored better on all questions pertaining to atomic structure (protons, neutrons, electrons, atomic number, mass number). Students both times were especially weak on questions pertaining to electron arrangement in atoms and ions.

Students in 1990 were more knowledgeable about number of valence electrons, isotopes and ionic bonds, but both groups had difficulty with property trends in the periodic table.

Unit B Concepts of Matter (14 items)
1981 items: 8-14, 19-24, 50
1990 items: 6-18, 34

Students were able to calculate molar mass, to balance simple equations and to convert mass to moles. The concept of a diatomic gas still presented a problem and significant figures were not well understood. Performance in all stoichiometric calculations has declined substantially between 1981 and 1990. The most noticeable decline occurred in questions that involved calculations related to molecules, to moles and molar volume.

Unit C Organic Chemistry (10 items)
1981 items: none
1990 items: 54-63

Students were more able to select the correct acid formula from a list of structural formulas than they were able to select the correct acid functional group. Their knowledge of family differentiation was good but knowledge about unsaturated hydro carbons was low. Students lacked ability to identify isomers or to predict reaction products such as esters.

Unit D Gases (11 items)
1981 items: 27-35, 62, 82
1990 items: 19-27, 46, 53

Overall, the performance of students in this subtest was consistent in 1981 and 1990. Students in 1990 were better in gas law calculations involving individual gas laws (Boyle's Law and Charles' Law) and the combined gas law. They did not do as well in the interpretation of graphs as the 1981 students. Molar mass as it is determined from density was poorly handled both times. Item 26 was difficult to interpret - most students chose the answer obtained by the incorrect substitution of data even though they could do that manipulation much better in item 27.

26. A gas has a volume of 3.00 L at -23° and 202.6 kPa pressure. What is the volume of the gas at 0°C and 101.3 kPa pressure?

1981	*1990*			
47.3%	*52.5%*	*	*A)*	*6.55 L*
15.5	*14.3*		*B)*	*5.49 L*
14.5	*14.2*		*C)*	*1.64 L*
16.9	*12.7*		*D)*	*1.50 L*
5.7	*6.3*		*E)*	*1.37 L*

27. A gas sample occupies 200 L at 95°C and 104 kPa pressure. Which of the following calculations will give the volume of the sample at 65°C and 108 kPa pressure?

1981	*1990*			
20.7%	*16.1%*		*A)*	$200 \times \frac{65}{95} \times \frac{104}{108} =$
14.3	*12.8*		*B)*	$200 \times \frac{95}{65} \times \frac{108}{104} =$
12.5	*14.1*		*C)*	$200 \times \frac{368}{338} \times \frac{108}{104} =$
21.5	*21.4*		*D)*	$200 \times \frac{368}{338} \times \frac{104}{108} =$
31.1	*35.5*	*	*E)*	$200 \times \frac{338}{368} \times \frac{104}{108} =$

Unit E Solutions (11 items)
1981 items: 36, 41, 43-45, 49, 51-54, 63
1990 items: 28-33, 35-38, 47

Students in the 1981 sample consistently outperformed the students in the 1990 sample in every question in this subtest. They performed considerably better in questions involving calculations.

In 1990 students performed best on questions relating vapour pressure to boiling point. They did not do as well on calculations pertaining to solution concentration. Knowledge about electrolytes was quite good.

Safety (7 items)
1981 items: 85, 87, 89-90, 92-93, 96
1990 items: 64-70

Results on the safety items were similar in 1981 and 1990. Both groups scored well on all items although the procedure for lighting a burner remained troublesome.

In order to determine any significant difference in student performance from 1981 to 1990, "t" tests were conducted using Bonferroni 5% level of significance for each subtest and the test as a whole. Table 4.2 presents means and confidence intervals for each subtest and the whole test in the 1981 and 1990 Chemistry 200 Assessment, together with the test of significance.

While it appears that the mean score of each subtest in 1990 was lower than that of 1981, only two subtests (Concepts of Matter and Solutions) showed a significant difference using the strict 5% level of significance.

Table 4.2

Analysis Summary for Chemistry 200 (1981 vs 1990)

Variable (Subtest)	Maximum Score Possible	Mean Score		Confidence Interval		Significance 1981 vs 1990
		1981	1990	1981	1990	
Periodic Table (MC)	17	9.624	9.417	(9.291,9.957)	(8.743,10.082)	NS
Concepts of Matter (MC)	14	8.347	7.152	(8.059,8.635)	(6.450,7.854)	*
Organic Chemistry (MC)	10		4.236		(3.511,4.961)	
Gases (MC)	11	5.616	5.347	(5.375,5.857)	(4.802,5.892)	NS
Solutions (MC)	11	5.938	5.077	(5.706,6.170)	(4.506,5.648)	*
Safety	7	4.614	4.337	(4.470,4.758)	(3.953,4.721)	NS
Gases (WR)	4	1.211	1.057	(1.076,1.346)	(0.765,1.349)	NS
Solutions (WR)	1	0.314	0.101	(0.266,0.362)	(0.046,0.156)	*
MC TOTAL (except Organic Chemistry)	60	34.140	31.330	(33.258,35.022)	(28.808,33.853)	NS
WR TOTAL	5	1.525	1.159	(1.369,1.681)	(0.831,1.487)	NS
CHEM TOTAL	65	35.665	32.489	(34.702,36.628)	(29.739,35.239)	NS

MC = Multiple Choice
WR = Written Responses
*** = Significant difference from 1981 to 1990**
NS = Not Significant

General Conclusions

The performance of students on all topics appeared to be satisfactory. Students in 1990 performed best in areas relating to descriptive chemistry and atomic structure. Their performance dropped off in areas relating to any form of calculation and problem solving.

Due to the low frequency of response on long answer questions, it was difficult to make comparisons on the understanding of concepts covered in both select-type and supply-type items.

Summary of cases where written responses were omitted

Subtest	1981	1990
Organic Chemistry	N/A	37.9%
Gases	43.4%	47.4%
Solutions	68.6%	89.5%

While the 1990 scores were generally lower than the 1981 scores, a significant difference was noted only in Concepts of Matter and Solutions.

Chemistry 300

The Chemistry 300 test consisted of the core topics only. There were five subtests (see Table 5.1 on page 85) which were comprised of both multiple choice items and written response items. Students performed much better on the multiple choice component than on the written-response section. The written-response items were completed by less than half of the students in 1990 as was the case in 1981. However, in 1990 fewer students attempted the written-response items than in 1981.

The student results of 1981 were based on a sample of 455 students out of a total of 2685 students enrolled in Chemistry 300. This represented 16.8% of the total population and a completion rate of 85% of the designated sample (537 students). In 1990, from the 28 schools randomly selected and 656 possible students, 567 students returned a completed Chemistry 300 Assessment for a completion rate of 86.4%. Table 5.1 provides a comparison of the mean performance of students for 1981 and 1990.

Table 5.1

Mean Performance for 1981 and 1990

	Core Units	1981		1990	
		No. of Items	Average Percent Correct	No. of Items	Average Percent Correct
A	Electronic Structure, Bonding, Periodic Table Elements	12	54	12	49
B	Reaction Rate and Chemical Equilibrium	11	58	11	49
C	Ionic Equilibria-Acids & Bases	12	55	12	53
D	Solubility	6	46	6	42
E	Oxidation-Reduction	15	39	15	35
	Safety	7	70	7	69

Unit A Electronic Structure, Bonding, Periodic Table (12 items)
1981 items: 53, 57-63, 77, 82-83, 87
1990 items: 40-47, 49, 51-52, 56

The students in 1981 performed better overall on this topic than the 1990 students.

Students in both 1981 and 1990 scored well on questions pertaining to electron configuration, electrons in orbitals, similarity in electron configuration in families and in the conditions necessary for the formation of ions and bonds.

Students in 1990 performed less well on questions pertaining to the stability of electron configuration (item 40), 38.9% in 1990 as compared to 52.8% in 1981, and to those elements that formed ionic bonds (item 44), 58.6% in 1990 as compared to 68.6% in 1981.

40. Consider the following electron configurations for neutral atoms:

I. $1s^2$ $2s^22p^6$ $3s^1$

II. $1s^2$ $2s^22p^6$ $4s^1$

Which statement does not apply?

1981	*1990*			
11.2%	*17.7%*		*A)*	*both configurations are sodium atoms*
13.5	*17.4*		*B)*	*energy is evolved in going from II to I*
9.0	*10.8*		*C)*	*both atoms have eleven protons*
52.8	*38.9*	*	*D)*	*atom II is more stable than atom I*
13.5	*15.1*		*E)*	*atoms I and II represent the same element*

Consider the following electron configurations for questions 43-46.

I	$1s^2$	$2s^22p^6$	
II	$1s^2$	$2s^22p^4$	
III	$1s^2$	$2s^22p^6$	$3s^1$
IV	$1s^2$	$2s^22p^6$	$3s^23p^5$
V	$1s^2$	$2s^22p^6$	$3s^23p^4$

44. The combination that could form an ionic bond would be:

1981	*1990*			
6.8%	*8.0%*		*A)*	*I and II*
9.5	*12.7*		*B)*	*II and V*
7.9	*14.1*		*C)*	*I and IV*
68.6	*58.6*	*	*D)*	*III and IV*
7.2	*6.6*		*E)*	*IV and V*

Unit B Reaction Rate and Chemical Equilibrium (11 items)
1981 items: 5-9, 14, 16-17, 24, 26, 28
1990 items: 1-5, 7-9, 13, 15, 16

The overall performance on this topic in 1990 was down slightly from 1981.

Although the results on many descriptive items in this topic were similar in 1981 and 1990, some items involving calculations on quantities present at equilibrium (item 15) or le Chatelier's Principle (item 9) were much more poorly answered in 1990 than in 1981. In 1990, 34% had item 15 correct as compared to 53% in 1981 and 44.3% had item 9 correct in 1990 as compared to 52.6% in 1981. It appears that students lacked understanding on the sign significance in heat of reaction questions and they had difficulty with the relative position of reactants and products in potential energy diagrams.

Use the following information for questions 7 - 9.

Sulfur dioxide, oxygen and sulfur trioxide are placed in a closed system and allowed to reach equilibrium at a fixed temperature.

$$2SO_3(g) + 188.0\ kJ \rightleftarrows 2SO_2(g) + O_2(g)$$

9. Which statement is incorrect?

1981	1990			
20.0	34.4		A)	*at equilibrium the products have more energy than the reactants*
13.7	9.2		B)	*an increase in pressure at constant temperature will produce more moles of* SO_3
4.9	5.0		C)	*an increase in temperature at constant pressure will produce more moles of* O_2
8.8	7.1		D)	*adding* SO_2 *to the system at constant temperature and pressure will decrease the amount of* O_2 *at the new equilibrium*
52.6	44.3	*	E)	*adding a catalyst will increase the amount of* SO_2 *and* O_2 *at equilibrium*

Use the following reaction information to answer questions 15 and 16.

$$A(g) + B(g) \rightleftarrows 2C(g) + D(g)$$

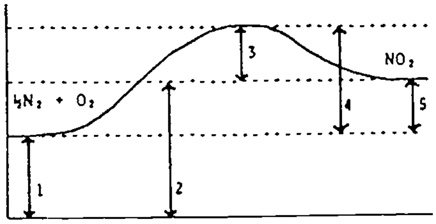
The initial concentration of A = 1.0 mol/L and B = 1.0 mol/L. At equilibrium C = 0.50 mol/L.

15. The concentration of D at equilibrium will be:

1981	1990			
23.1	34.3		A)	1.0 mol/L
6.5	3.7		B)	0.75 mol/L
13.0	19.5		C)	0.50 mol/L
52.6	34.9	*	D)	0.25 mol/L
4.7	7.6		E)	2.0 mol/L

There was a severe decline in performance in item 4. This may be due to the omission of the Δ sign for ΔH or the print error in the correct answer choice (B) which read 67.6% instead of 67.8%. This may have led to the large choice of (E).

Use the following diagram to answer questions 1 - 5.



4. *The graph represents the equation:*

$$\frac{1}{2}N_2(g) + O_2 \rightleftharpoons NO_2(g) \qquad H = 33.9\ kJ/mol$$

The energy required to produce 2.00 moles of NO_2 is:

1981	*1990*			
6.1%	*4.5%*		*A)*	*135.2 kJ*
82.0	*39.0*	*	*B)*	*67.6 kJ*
5.6	*4.8*		*C)*	*33.8 kJ*
1.8	*11.4*		*D)*	*16.9 kJ*
4.5	*40.3*		*E)*	*none of the above*

Unit C Ionic Equilibria - Acids and Bases (12 items)
1981 items: 29-38, 40, 84
1990 items: 17-27, 53

The results were similar in both 1981 and 1990. Neither group did well on the reaction of a base (item 26) or on K_a calculations (item 27). Both times less than 25% of the students had item 26 correct and 31% had item 27 correct in 1990 compared to 38% in 1981.

26. *A solution is identified as a strong base. The solution would not:*

1981	*1990*			
20.7	*22.8*		*A)*	*be a good electrical conductor*
10.1	*12.3*		*B)*	*be highly ionized*
25.2	*23.[illegible]*	*	*C)*	*react with zinc metal*
9.2	*11.7*		*D)*	*have a slippery feel*
34.8	*30.1*		*E)*	*turn phenolphthalein pink*

27. *A 1.00 mol/L solution of a weak acid, HX, has a hydrogen ion concentration of 1.0×10^{-5} mol/L. The K_a for the acid is:*

1981	*1990*			
38.2	*30.9*	*	*A)*	1.0×10^{-10}
42.3	*45.2*		*B)*	1.0×10^{-5}
4.8	*8.4*		*C)*	1.0×10^{0}
12.0	*13.0*		*D)*	1.0×10^{5}
2.7	*2.5*		*E)*	1.0×10^{10}

Basic theory on acid-base descriptive chemistry was answered well by the 1981 and 1990 groups (items 18,19,25). The range of scores for these items in the two years was 56% - 81%. Any questions involving calculations were performed better by the 1981 students.

18. The conjugate base of $HClO_3$ (aq) is:

1981	*1990*			
14.8	*9.5*		*A)*	ClO_2^-
10.1	*9.2*		*B)*	Cl^-
55.5	*61.3*	*	*C)*	ClO_3^-
14.4	*11.7*		*D)*	$H_2ClO_3^+$
5.2	*8.3*		*E)*	$HClO_2$

19. The pH of a solution containing an equal number of moles of HCl and NaOH will be (at 25°C):

1981	*1990*			
14.4	*11.6*		*A)*	*1*
5.6	*6.1*		*B)*	*3*
78.0	*76.6*	*	*C)*	*7*
1.3	*3.6*		*D)*	*9*
0.7	*2.1*		*E)*	*11*

25. Which of the following pH ranges would represent the most acidic solution?

1981	*1990*			
80.9	*80.7*	*	*A)*	*1-3*
1.8	*3.4*		*B)*	*4-6*
2.5	*2.1*		*C)*	*6-8*
2.2	*2.3*		*D)*	*8-11*
12.6	*11.5*		*E)*	*12-14*

Unit D Solubility (6 items)
1981 items: 11, 18-19, 22, 25, 81
1990 items: 6, 10-12, 14, 50

Performance on this topic was marginally better in 1981.

Students in both years had difficulty in item 11 where it was first necessary to convert to moles. Interpretation of an equation to set up a K_{sp} expression was weak.

11\. *The solubility of $BaCO_3$ is 1.4×10^{-2} g/L. The K_{sp} will be:*

1981	1990			
1.4	3.8		A)	2.0×10^{8}
17.4	16.9	*	B)	5.0×10^{-9}
31.8	34.8		C)	2.0×10^{-4}
26.5	17.5		D)	7.0×10^{-5}
22.9	27.0		E)	1.4×10^{-4}

Students included a solid in the denominator (item 10).

10\. *The solubility of calcium hydroxide can be represented by the equation:*

$$Ca(OH)_2(s) \rightleftharpoons Ca^{2} + (aq) + 2OH^-(aq)$$

1981	1990			
6.1	9.2		A)	$\frac{[Ca^{2+}]\ [2OH^-]}{[Ca(OH)_2]}$
29.5	32.7		B)	$\frac{[Ca^{2+}]\ [OH^-]^2}{[Ca(OH)_2]}$
51.8	45.9	*	C)	$[Ca^{2+}]\ [OH^-]^2$
5.4	1.9		D)	$[CA^{2+}] + [OH^-]^2$
7.2	10.2		E)	$[Ca^{2+}]\ [2OH^-]^2$

A good knowledge of the relationship between the size of the K_{sp} and the relative solubility of a substance was in evidence (Item 6). Approximately 48% of students answered this question correctly on both occasions.

6\. *The solubility of CuC1 is 5.7×10^{-4} mol/L. The K_{sp} of CuC1 is:*

1981	1990			
26.1	19.2		A)	5.7×10^{-8}
48.5	47.4	*	B)	3.2×10^{-7}
16.6	20.1		C)	3.2×10^{-4}
3.4	5.3		D)	3.1×10^{-6}
5.4	8.0		E)	1.7×10^{3}

Unit E **Oxidation-Reduction (15 items)**
1981 items: 41-52, 73, 85-86
1990 items: 28-39, 48, 54-55

Performance on this topic was low both times and slightly lower in 1990. This may have been due, in part, to its location in the test.

Students performed well on assigning oxidation numbers and using terminology. They performed very poorly on balancing oxidation reduction reactions (item 28). Twenty-eight percent (28%) of students had this item correct in 1990 as compared to 37.1% in 1981.

Consider the following unbalanced oxidation-reduction for questions 28-30.

$$Fe^{2+}(aq) + MnO_4^-(aq) + H^+(aq) \rightarrow Fe^{3+}(aq) + Mn^{2+}(aq) + H_2O$$

28. When the equation is balanced, the coefficient for the $Fe^{3+}(aq)$ will be:

1981	1990			
24.9	38.4		A)	1
26.5	20.3		B)	2
9.0	9.3		C)	3
2.5	3.9		D)	4
37.1	28.1	*	E)	5

Neutralization involving volumes was well answered both times but neutralization involving mass was very poorly answered both times. The ability to predict spontaneity of an oxidation-reduction reaction was very poorly answered (item 39), 20% in 1990 and 28% in 1981. Interpretation of electrochemical cell diagrams and application of the theory involved was similar both times but low, perhaps due to the timing of the topic.

39. Which reaction does not occur spontaneously?

1981	1990			
5.5	7.6		A)	$Ag^+ + Cu(s)$
11.0	9.8		B)	$Cu^2 + Fe(s)$
28.1	20.0	*	C)	$Cr^3 + Ni(s)$
32.0	38.5		D)	$Cl^- + MnO_4^- + H^+$
23.5	23.8		E)	$Br_2(l) + Ag(s)$

Safety (7 items)
1981 items: 89, 91, 93-94, 96-97, 100
1990 items: 57-63

In 1990, the performance was similar to 1981. The results in Chemistry 300 were similar to the results in Chemistry 200 for the same questions. The procedure for lighting the burner proved to be a problem. Perhaps, the problem was linked to the clarity or interpretation of the question.

In order to determine any significant difference in student performance from 1981 to 1990, "t" tests were conducted using Bonferroni 5% level of significance for each subtest. Table 5.2 presents means and confidence intervals for each subtest in the 1981 and 1990 Chemistry 300 Assessment together with the test of significance.

Table 5.2

Analysis Summary for Chemistry 300 (1981 vs 1990)

Variable (Subtest)	Maximum Score Possible	Mean Score		Confidence Interval		Significance 1981 vs 1990
		1981	1990	1981	1990	
Electronic Structure, Bonding, Periodic Table (MC)	12	6.420	5.857	(6.114,6.726)	(5.143,6.572)	NS
Reaction Rate and Chemical Equilibrium (MC)	11	6.387	5.407	(6.103,6.671)	(4.818,5.997)	*
Ionic Equilibria - Acids & Bases (MC)	12	6.585	6.412	(6.281,6.889)	(5.722,7.102)	NS
Solubility (MC)	6	2.774	2.522	(2.609,2.939)	(2.175,2.869)	NS
Oxidation-Reduction (MC)	15	5.826	5.263	(5.491,6.161)	(4.636,5.890)	NS
Safety	7	4.892	4.855	(4.729,5.055)	(4.514,5.197)	NS
Electronic Structure, Bonding, Periodic Table (WR)	7	2.844	2.086	(2.643,3.045)	(1.623,2.549)	*
Reaction Rate and Chemical Equilibrium (WR)	5	1.554	1.049	(1.781,1.727)	(0.643,1.455)	NS
Solubility (WR)	3	0.903	0.523	(0.770,1.036)	(0.237,0.809)	NS
Oxidation Reduction (WR)	5	1.215	0.835	(1.047,1.383)	(0.464,1.206)	NS
MC TOTAL	63	32.884	30.317	(31.792,33.976)	(27.543,33.090)	
WR TOTAL	20	6.516	4.492	(6.059,6.975)	(3.197,5.788)	*
CHEM TOTAL	83	39.450	34.809	(37.969,40.831)	(30.812,38.806)	NS

MC = Multiple Choice
WR = Written Responses
*** = Significant difference from 1981 to 1990**
NS = Not Significant

General Conclusions

Student performance seems to have declined in all areas where calculations were involved but seems to have remained relatively consistent in the descriptive areas.

Written response answers were frequently blank.

Summary of cases where written responses were omitted:

Subtest	1981	1990
Electronic Structure...	13.8%	18.2%
Reaction Rate	35.2%	46.6%
Solubility	56.5%	71.1%
Oxidation-Reduction	46.8%	87.1%

The 1990 student scores were generally lower than those of 1981. However, a significant difference was noted only in Reaction Rate and Chemical Equilibrium and in the written response questions as a whole.

Recommendations

From examining the 1990 results it appears that student performance had not improved since 1981 and even showed greater weakness in areas involving calculations. Therefore, it is recommended that:

1. **Manitoba Education and Training review the recommendations of the Chemistry Assessment 1981 Final Report and implement strategies that would enable teachers to deliver a curriculum resulting in higher student performance. (M,S)**

2. **Manitoba Education and Training review the recommendations of the Chemistry Assessment 1981 Final Report and examine the suggested restructuring of the Chemistry 200 and 300 programs that may allow for better integration of content.**

CHAPTER 7

Assessment Summary

Purpose:

The 1990 Science Assessment provides information from student results and teacher questionnaires to assist Manitoba Education and Training in its curriculum development process; to enable schools and school divisions to determine the extent to which the respective Science curricula have been learned; and to assist teachers, schools and divisions in planning for effective instruction and assessment.

Test Population:

The provincial test sample consisted of students only from public schools in Manitoba. In programs where only a portion of the student population was tested, some schools and divisions opted to test the rest of their students in an effort to obtain a more complete profile of school and division performance in the respective Science courses. Also, several private schools conducted the assessment among their population and benefitted from the information collected in a similar way.

Test Development:

Each test, with the exception of the comparison testing of Chemistry 200 and 300, was piloted prior to its final administration. Most of the Chemistry 200 and 300 test items had been piloted prior to the 1981 administration. Through regional meetings throughout the province, teachers and administrators were able to provide input to assist the Technical Advisory Committees in establishing testing procedures and developing the tests. The actual test development process, analysis of results and formulation of recommendations provided an excellent professional development opportunity for the many teachers who were part of each Technical Advisory Committee. It is anticipated that the loss of instructional time on account of committee meetings will have great "pay off" for the students of these committee members and their colleagues as well.

Test Results

Each assessment revealed similar results with respect to multiple choice items and long answer type questions. Generally, the mean performance of students on the multiple choice portion of the test was higher than that of the long answer or supply-type segment. The long answer questions were often left undone. Where Option topics were tested, students did not perform as well as they did on the Core topics. The limitation of time for completing the course satisfactorily prevailed as a popular reason for the low performance in the Option areas.

The comparison testing of Chemistry 200 and 300 showed that the performance of students in 1990 was similar to that of 1981 in most areas. However, there was a decline of performance in some areas in 1990 in both courses. On both occasions, students performed better on the multiple choice segment than on the long answer type questions. In fact, fewer students completed the long answer questions in 1990 than in 1981.

Teacher Survey:

The return rate of Teacher questionnaires in each of the Science courses surveyed was quite high (90-100%). The data show that teachers of the Science courses have adequate academic and professional training and have participated regularly in inservices. For the most part they are satisfied with their instructional facilities and materials even though they would like to have greater access to a science laboratory (available only 60% of instructional time) and an organized list of meaningful laboratory activities for the respective courses. Teachers seem to favour workshops in specific topic areas and successful innovative classroom strategies. There is the general feeling among the teachers who provided feedback (58%) that the standard of performance would be much higher if students entered the "00" Science courses with the necessary pre-requisites. There appears to be some crowding in these courses due to a lack of alternatives for some students and errant screening for admission.

General Conclusions:

Every member of the Technical Advisory Committees felt that greater emphasis ought to be placed on provincial assessments if students are to take them seriously. The results should have significant impact for program modification. Students and teachers require more time to cover the prescribed curriculum adequately. Teachers would appreciate greater support through the provision of resource banks with laboratory activities, projects, questions and answers and assessment instruments.

Recommendations

The following is a summary of some of the key recommendations that are common to each report:

Manitoba Education and Training

Manitoba Education and Training has been encouraged to:

1. review the curriculum content for each course with the aim of restructuring topic areas for appropriateness and proper sequencing through the different levels. It is the opinion of many teachers that additional curricular areas have been introduced into the high school program from time to time and this has led to the erosion of time allotted for the prescribed Science curriculum;

2. review prescribed textbooks and consider replacement by more up-to-date texts;

3. sponsor workshops in specific topic areas so as to strengthen teachers' skills and knowledge; and

4. assist in the establishment of a resource bank of laboratory activities, projects and assessment instruments for each course and make these accessible to teachers.

Faculties of Education

Faculties of Education have been encouraged to:

1. provide specific course training dealing with science content and laboratory activities; and
2. provide training in assessment techniques and the implications of these for instruction.

School Divisions

Divisions have been encouraged to:

1. ensure adequate instructional facilities, including well-equipped laboratories;
2. facilitate ongoing inservicing of teachers in specific topic areas and classroom strategies.

Teachers

Teachers are encouraged to:

1. take advantage of opportunities for professional development;
2. network with colleagues to share strategies and new trends; and
3. prepare students to write different forms of assessment.

APPENDICES

SCIENCE ASSESSMENT 1990

TEACHER QUESTIONNAIRE
SCIENCE 100

I. TEACHER BACKGROUND

A. How many (academic or professional) university/college courses have you taken in each of the following disciplines? (Count 6 credits as one course and include both undergraduate and graduate courses, and check each that applies.)

	Number of Courses			
	0	½ - 1	more than 1	No Response
1) Biological Sciences/Environmental Sciences	17.1%	15.3%	55.6%	12.0%
2) Chemistry	6.0	7.9	80.6	5.6
3) Physics	10.6	29.6	48.6	11.1
4) Earth Sciences/Geology/Astronomy	26.4	21.3	28.7	23.6
5) Anthropology/Archaeology/ Behaviourial Sciences	20.4	23.1	32.9	23.6
6) Computer Sciences	35.2	16.7	15.7	32.4
7) Mathematics	6.9	16.7	68.1	8.3
8) Other (specify) ________	0.5	0.5	0.9	98.1

B. In which major discipline area(s) outside of Science 100 have you taught in the last 3 years ***(check each that applies)***?

None	Chemistry	Biololgy	Physics	Computer Science	Mathematics	Junior High School Science	Other (specify)
2.3	45.8	31.9	37.5	6.9	44.9	37.0	22.7

	Yes	No	No Response
C. Do you teach the Science 101 program?	48.6	50.9	0.5

D. How many years have you taught the Science 100 program?

1	2	3	4	5	6	7 or more	No Response
13.4	6.5	9.7	6.0	5.1	2.3	56.0	0.9

	Yes	No	No Response
E. Have you taken any university/college science-related courses within the last 5 years?	19.4%	78.7%	1.9%

If "yes", in what program are/were the courses?________________________

F. Have you attended inservice work related to Science 100? If "yes", specify the topic and source of the inservice work (e.g., half-day inservice on laboratory skills sponsored by the division).

1) Workshop(s) 34.7 YES → Topic ________________________
55.6 NO Source ________________________
9.7 NR

2) Seminar(s) 13.4 YES → Topic ________________________
63.9 NO Source ________________________
22.7 NR

II. SCHOOL ORGANIZATION

	Mean	Median
A. Indicate the number of Science 100 groups/classes you teach that are:		
full-year/non-semestered	1.5	1.0
semestered	1.8	2.0
other (e.g., 9-month school-year) (specify) ____	1.0	1.0

	Yes	No	No Response
B. Do you have a combined Science 100-Science 101 classroom?	15.3%	81.9%	2.8%

	Mean	Median
C. How many hours of instruction in total do your Science 100 classes receive (on average)?	111.6	110.0
D. How much time do you spend per cycle, for each Science 100 class, on these?		
1) preparation for laboratory activities	2.0	1.5
2) preparation of classroom lessons	2.4	2.0
3) marking student work (tests, lab reports, etc.)	3.1	2.0
E. How many hours of preparation time per cycle does your timetable afford you?	4.2	4.0
F. What is your average class size for Science 100?	23.8	25.0

III. SCHOOL FACILITIES

A. In what type of room do you teach your Science 100 class *(check one)*?

regular classroom	9.7%	
science laboratory	49.5	
combination regular classroom/laboratory	38.9	
other	0.5	(specify) ______
no response	1.4	

B. For what percentage of class time would you have a lab facility available to your Science 100 classes *(check one)*?

0%	10-20%	20-30%	30-40%	40-50%	50-60%	60% or more	No Response
0.9	5.1	2.8	0.5	3.2	1.9	84.3	1.4

C. Which of the following does your laboratory facility contain *(check each that applies)?*

95.4	1)	tables/counters	69.4	7)	audio-visual equipment
93.1	2)	storage room for science materials/equipment	94.0	8)	adequate lighting
86.6	3)	work space for student labs	87.5	9)	propane gas/natural gas
57.4	4)	preparation room	28.2	10)	cold storage/refrigerator
91.2	5)	hot and cold water outlets, and sinks	49.5	11)	metal storage cabinet
94.4	6)	electrical outlets	54.6	12)	adequate ventilation

D. Which safety equipment does your laboratory facility contain? *(Check each that applies.)*

90.3	1)	eye wash station	34.3	7)	cabinet (safety goggles)
20.4	2)	main power switch/GFCI (groundfault circuit interrupt)	97.2	8)	fire extinguishers (ABC type)
91.7	3)	master gas shutoff	56.9	9)	approved first aid kit
15.3	4)	light indicator for gas shutoff	30.6	10)	deluge shower
87.0	5)	fire blanket	55.6	11)	fume hood
91.7	6)	safety goggles, sufficient for entire class	2.8	12)	other, specify ______

	Yes	No	No Response
E. Do you have a lab assistant for your Science 100 class?	21.8	76.9	1.4
F. Are your laboratory supplies adequate?	81.5	15.7	2.8

If not, identify in what way(s) they are inadequate: ______

IV. CURRICULUM GUIDE

	Yes	No	No Response
A. Are you using the 1982 Manitoba Curriculum Guide for teaching Science 100?	94.9%	2.3%	2.8%

B. In teaching Science 100 what emphasis do you place on the objectives in the Guide for the units you teach? *(check one)*

Not at All	To a Lmited Extent	To a Moderate Extent	To a Great Extent	No Response
0.9	9.3	49.1	38.4	2.3

C. Which of the following units do you teach in your Science 100 program? *(Check each that applies.)*

Core Units

98.6 1) Measurement and Experimentation

98.6 2) Characteristics of Matter

94.0 3) Separation of Substance

Required Options

51.4 4) Fossil Fuels

57.4 5) Motion and Collisions

73.1 6) Cells and Cancer

Other Options

24.5 7) Nutrition

10.6 8) Air and its Components

51.9 9) Particle Theory

35.2 10) Local options, specify

	Yes	No	No Response
D. Do you follow the SI metric system?	98.6	--	1.4
E. Is your laboratory equipment SI compatible?	98.1	0.5	1.4

V. TEACHING RESOURCES AND MATERIALS

A. Which of the following teaching resources and materials do you use in your Science 100 program? *(Check each that applies.?*

1. Compulsory Topics

43.5% (i) U Haber-Schaim, et al., Introductory physical science. Prentice-Hall.

66.2 (ii) W. A. Andrews, et al., Physical science: An introductory study. Prentice-Hall

14.4 (iii) Other, specify ______

2. Required Options

52.3 (i) Packaging passengers (ISIS)

28.2 (ii) Let's eat (ISIS)

73.1 (iii) Cells and cancer (ISIS)

47.7 (iv) Fossil fuels (ISIS)

20.8 (v) Other, specify ______

3. Other Options

19.0 (i) U. Haber-Schaim, et al., Introductory physical science. Prentice-Hall.

31.5 (ii) W. A. Andrews, et al., Physical science: An introductory study. Prentice-Hall.

3.7 (iii) G. Tracy, et al., Modern physical science. Holt Canada.

7.9 (iv) Other, specify ______

VI. TEACHING ACTIVITIES AND METHODOLOGY

A. What approach do you follow in implementing the Science 100 program *(check one)*?

2.3 Individualized approach

37.0 Group-centered approach

59.7 Group-centered and individualized approach

0.9 Other, specify ______

B. Approxim. 'y what percentage of your allotted time for Science 100 would be used for each of the following activities?

	0-10%	10-20%	20-30%	30-40%	40-50%	50-60%	Over 60%	No Response
1) Teacher lecture	7.4%	30.6%	27.8%	14.8%	8.8%	8.3%	1.4%	0.9%
2) Teacher demonstration	41.2	40.3	12.5	2.8	.9	0.5	--	1.9
3) Student performed laboratory activities	1.9	5.6	22.2	21.8	19.9	13.4	14.4	0.9
4) Individually prescribed program	31.9	17.6	10.6	3.7	2.3	0.5	1.4	31.9

C. How often do you engage your Science 100 students in each of the following activities? Write in the appropriate number from the scale below.

1. ***Hardly ever (e.g., 0, 1 or 2 times during course)***
2. ***Occasionally (e.g., 1 time per cycle)***
3. ***Frequently (e.g., 2 or 3 times per cycle)***
4. ***Very Frequently (almost every biology class period)***

	1	2	3	4	No Response
Classroom work					
1) listening to the teacher's lesson, taking notes	8.8	31.5	44.4	13.9	1.4
2) reading from textbook, or from other textual materials	29.6	37.5	25.5	6.0	1.4
3) working on questions given in a textbook; doing worksheets	0.9	25.9	53.7	18.1	1.4
4) discussing assignments and solutions	9.3	15.3	47.2	33.8	1.4
Laboratory Work					
5) designing and preparing their own experiments (pre-lab work)	55.6	28.2	10.2	3.2	2.8
6) preparing experiments from a set of instructions	9.7	29.2	42.1	17.6	1.4
7) conducting experiments	0.9	15.7	50.9	31.9	0.5
8) describing/reporting observations including use of tables and graphs (post-lab work)	2.3	28.7	43.1	25.0	0.9
9) analyzing results, drawing conclusions, and preparing research report (post-lab work)	2.3	35.6	38.9	22.2	0.9
10) reviewing/practicing laboratory skills and safety procedures	18.1	41.7	25.0	13.0	2.3
Other					
11) applying information/inferences to new problem situations	23.6	46.8	18.5	3.2	7.9
12) doing library research, or other forms of non-experimental research	73.1	18.1	1.9	--	6.9

VII. EVALUATION

A. In evaluating student growth in Science 100, what emphasis do you place on the following methods of evaluation? Rate each method.

		No Emphasis	Some Emphasis	Great Emphasis	No Response
1)	In-class and homework assignments	4.6%	60.2%	33.3%	1.9%
2)	Lab reports	0.9	49.5	48.6	0.9
3)	Teacher-made tests:				
	a) multiple-choice, true-false, matching items	6.0	55.1	35.2	3.7
	b) non-numeric questions of recall (definitions, etc.)	7.4	69.0	17.6	6.0
	c) non-numeric questions of applications, explanations, and derivations	1.9	61.1	32.9	4.2
	d) lab skills tests	19.4	56.5	16.2	7.9
4)	Individual projects or research papers	44.4	45.4	5.1	5.1
5)	Group projects or research papers	62.0	28.2	2.3	7.4
6)	Science fair projects	75.9	16.7	1.9	5.6
7)	Standardized multiple-choice or true-false tests	28.2	50.0	17.1	4.6
8)	General attitude in class and work habits	16.2	58.8	20.8	4.2
9)	Other, specify ______	--	3.2	9.3	87.5

		Yes	No	No Response
B.	Do your Science 100 students write final exams?	94.4	4.6	0.9
	If yes, are there exemptions from Science 100 final exams available to your students?	36.1	58.3	5.6

C. What procedures do you use to mark students' lab reports ***(check one)***?

1.4 I do not mark any lab reports.

23.6 I mark each student's lab report for a sample of lab activities.

5.6 I mark a sample of students' lab reports for each lab activity.

59.7 I mark each student's lab report for all lab activities.

2.3 The students mark lab reports with my guidance.

7.4 Other, specify ______________________________

VIII. STUDENT EXTRACURRICULAR ACTIVITIES RELATED TO SCIENCE

A. What science-related activities are available to your students outside of Science 100 classes? ***(check each that applies)***

9.3%	1)	Science club	9.3%	4)	Other, specify ___________
10.6	2)	Environmental club	35.2	5)	None
47.2	3)	Science fair			

B. What science-related tours/field trips are available to your Science 100 students?

1) during regular class (specify)____

2) extra curricular (specify) ____

IX. FUTURE DIRECTIONS

A. How would you change the Science 100 curriculum outline to prepare students for the 21st century?

____

B. What types of Science inservices/professional development would you be interested in attending ***(check each that applies)***?

32.4	1)	content background (core topics)
28.7	2)	content background (optional topics)
53.2	3)	innovative teaching strategies (e.g., co-operative learning)
50.5	4)	use of the microcomputer in the biology classroom
33.8	5)	methods for adapting the curriculum
22.2	6)	assessment techniques
56.9	7)	update on the newest developments in biology
69.9	8)	new lab activities to augment the Science 100 program
59.7	9)	technological applications (e.g., science, society, and technology)
7.9	10)	other (specify)________________________________

SCIENCE ASSESSMENT 1990

TEACHER QUESTIONNAIRE
BIOLOGY 200

I. TEACHER BACKGROUND

A. How many (academic or professional) university/college courses have you taken in each of the following disciplines? (Count 6 credits as one course and include both undergraduate and graduate courses, and check each that applies.)

	Number of Courses			
	0	½ - 1	more than 1	No Response
1) Biological Sciences/Environmental Sciences	3.1%	8.5%	87.6%	0.8%
2) Chemistry	9.3	17.8	61.2	11.6
3) Physics	21.7	37.2	17.8	23.2
4) Earth Sciences/Geology/Astronomy	23.3	20.2	27.9	28.7
5) Anthropology/Archaeology/ Behaviourial Sciences	14.0	20.9	40.3	24.8
6) Computer Sciences	33.3	14.7	13.2	38.8
7) Mathematics	18.6	17.1	42.6	21.7

B. In which major discipline area(s) outside of Biology have you taught in the last 3 years ***(check each that applies)***?

None	Chemistry	Physics	Computer Science	Mathematics	Junior High School Science	Other (specify)
13.2	24.8	14.0	7.0	26.4	47.3	42.6

C. Do you teach:

	Yes	No	No Response
1. the Biology 300 program?	78.3	17.8	3.9
2. the Biology 201 or 301 programs?	52.7	36.4	10.9

D. How many years have you taught the Biology 200 program?

1	2	3	4	5	6	7 or more
9.3	7.8	7.0	3.9	3.9	2.3	65.9

	Yes	No	No Response
E. Have you taken any university/college science-related courses within the last 5 years?	23.3%	75.2%	1.6%

If "yes", in what program are/were the courses?________________________

F. Have you attended inservice work related to Biology 200? If "yes", specify the topic and source of the inservice work (e.g., half-day inservice on laboratory skills sponsored by the division).

1) Workshop(s) 45.7 YES → Topic ________________

43.4 NO Source______________________________

10.9 NR

2) Seminar(s) 31.0 YES → Topic ______________________________

45.0 NO Source______________________________

24.0 NR

G) To which professional organizations relating to Biology teaching do you belong ***(check each that applies)***?

72.1 1) STAM (Science Teachers' Association of Manitoba)

40.3 2) Biology Teachers' Organization of Manitoba

1.6 3) Canadian Association of Science Educators

2.3 4) National Science Teachers' Association

12.4 5) Other, specify ____________________

II. SCHOOL ORGANIZATION

	Mean	Median
A. Indicate the number of Biology 200 groups/classes you teach that are:		
full-year/non-semestered	1.7	1.0
semestered	1.8	2.0
other (e.g., 9-month school-year) (specify) ____	1.0	1.0

	Yes	No
B. Do you have a combined Biology 200-Biology 201 classroom?	15.5%	84.5%

	Mean	Median
C. How many hours of instruction in total do your Biology 200 classes receive (on average)?	112.7	110.0
D. How much time do you spend per cycle, for each Biology 200 class, on these?		
1) preparation for laboratory activities	2.3	1.0
2) preparation of classroom lessons	3.7	2.0
3) marking student work (tests, lab reports, etc.)	4.1	2.5

		Mean	Median
E.	How many hours of preparation time per cycle does your timetable afford you?	4.1	4.0
F.	What is your average class size for Biology 200?	24.4	25.0

III. SCHOOL FACILITIES

A. In what type of room do you teach your Biology 200 class *(check one)*?

regular classroom	13.2%
science laboratory	45.0
combination regular classroom/laboratory	38.0
other	3.1 (specify) ____
no response	0.8

B. For what percentage of class time would you have a lab facility available to your Biology 200 classes *(check one)*?

0%	10-20%	20-30%	30-40%	40-50%	50-60%	60% or more
6.2	7.8	5.4	2.3	–	–	78.3

C. How adequate are the following physical facilities for teaching Biology 200 to your classes. Please rate your facilities on this 4-point scale.

	Very Inadequate	Inadequate	Adequate	More Than Adequate	Not Applicable	No Response
1) tables/counters	3.9	9.3	51.9	32.6	1.6	0.8
2) storage space for biology materials/equipment	2.3	18.6	46.5	31.0	1.6	--
3) amount of work space per student	4.7	20.9	55.0	18.6	--	0.8
4) preparation rooms	10.1	16.3	50.4	16.3	6.2	0.8
5) hot and cold water outlets, and sinks	6.2	14.7	50.4	27.1	1.6	--
6) electrical outlets	--	10.9	53.5	34.1	0.8	0.8
7) audio-visual equipment	2.3	7.8	58.9	30.2	0.8	--
8) lighting	0.8	3.1	67.4	27.1	--	1.6
9) gas outlets	5.4	5.4	54.3	29.5	4.7	0.8
10) cold storage/refrigerator	17.8	14.0	46.5	15.5	3.9	2.3
11) separate storage cabinet for chemicals	8.5	17.1	51.2	17.1	4.7	1.6
12) locked metal storage cabinets for volatiles	19.4	17.1	40.3	12.4	8.5	2.3
13) ventilation	14.7	26.4	48.8	8.5	0.8	0.8
14) other, specify ___	2.3	0.8	1.6	0.8	--	94.6

D. Which of the following safety equipment does your laboratory facility contain? ***(Check each that applies.)***

79.8%	1) eye wash station	70.5%	6) safety goggles, sufficient for entire class
17.8	2) main power switch/GFCI (groundfault circuit interrupt)	24.0	7) cabinet (safety goggles)
84.5	3) master gas shutoff	91.5	8) fire extinguishers (ABC type)
12.4	4) light indicator for gas shutoff	55.0	9) approved first aid kit
72.1	5) fire blanket	16.3	10) deluge shower
		2.3	11) other, specify ___

	Yes	No	No Response
E. Do you have a lab assistant?	26.4	72.9	0.8

If yes, what type of assistant do you have? ***(Check each that applies.)***

21.7 paid adult assistant

3.9 paid student assistant

\- volunteer adult assistant

1.6 volunteer student assistant

	Yes	No	No Response
F. Is your laboratory equipment adequate?	77.5	20.2	2.3

If not, what lab equipment (or facilities) are you lacking that you think is necessary to teach the Biology 200 curriculum?

____

	Yes	No	No Response
G. Are your laboratory supplies adequate?	86.0	10.9	3.1

If **not**, identify in what way(s) they are inadequate: ________________________

IV. CURRICULUM GUIDE

	Yes	No	No Response
A. Are you using the current Biology 200 Manitoba Curriculum Guide?	98.4	0.8	0.8

B. In teaching Biology 200, to what extent do you base your program on the objectives in the Guide?

Not at All	To a Lmited Extent	To a Moderate Extent	To a Great Extent	No Response
--	4.7%	31.0%	63.6%	0.8%

C. How appropriate are the following aspects of the curriculum in terms of the students you teach? Please rate the aspects on this 4-point scale.

	Not Appropriate At All 1	Not Very Appropriate 2	Moderately Appropriate 3	Very Appropriate 4	Don't Know	No Response
1) objectives	--	2.3	41.9	51.9	1.6	2.3
2) content/topics balance	1.6	3.9	35.7	55.8	0.8	2.3
3) suggested activities (lab)	1.6	9.3	52.7	33.3	--	3.1
4) recommended textual material	0.8	11.6	49.6	32.6	3.1	2.3
5) recommended sources of labs	2.3	13.2	51.9	24.8	4.7	3.1

D. Which of these core units do you teach in your Biology 200 program *(check each)*?

Core Units

98.4	I.	Cell structure and function	93.8	VI.	Excretory System
96.9	II.	Biochemistry	87.6	VII.	Nervous System
97.7	III.	Digestion	84.5	VIII.	Endocrine System
98.4	IV.	Transportation	79.1	IX.	Reproduction and Development
98.4	V.	Respiratory System			

E. If some core units were not completed, please identify why.

____

F. Check each option unit you teach; indicate the approximate amount of classroom time you spend on it.

		Option	Number of Hours Spent Mean	Median
36.4%	a)	Cancer	2.1	2.0
16.3	b)	Basic Ecology	4.5	4.0
20.[illegible]	c)	Environmental Issues	3.3	2.0
55.0	d)	Heart Health	3.3	2.5
11.6	e)	Human Behaviour	3.5	2.0
9.3	f)	Aging	2.0	2.0
29.5	g)	Disease Causing Organisms in Humans	4.4	3.0
51.9	h)	Sexually Transmitted Diseases	2.7	2.0
29.5	i)	Support and Movement	4.7	5.0
41.1	j)	Project or Research	5.6	4.0

G. If you do not teach any of the options, please identify why.

____

V. TEACHING RESOURCES AND MATERIALS

A. What is the principal text you use for teaching Biology 200 ***(check one)***?

11.6	J. E. Rahn, Biology: The science of life. Macmillan.
37.2	E. J. Kormondy & B. E. Essenfeld, Biology. Addison-Wesley.
30.2	G. S. Berry, et. al., Biology of ourselves: A study of human biology. Wiley and Sons.
17.1	Other(s), please specify: ______________________
3.9	No Response

B. How satisfied are you with the text(s) you use?

Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied	No Response
3.9	15.5	58.9	20.9	0.8

C. List other texts/textual materials you use to supplement the principal text.

Text/Textual Materials

____

VI. TEACHING ACTIVITIES AND METHODOLOGY

A. What approach do you follow in implementing the Biology 200 program *(check one)*?

4.7%	Individualized approach
43.4	Group-centered approach
50.4	Group-centered and individualized approach
1.6	No Response

B. Approximately what percentage of your allotted time for Biology 200 would be used for each of the following activities?

	0-10%	10-20%	20-30%	30-40%	40-50%	50-60%	Over 60%	No Response
1) Teacher lecture	3.1	3.9	8.5	18.6	25.6	25.6	14.0	0.8
2) Teacher demonstration	47.3	30.2	14.7	.8	--	--	--	7.0
3) Student performed laboratory activities	4.7	36.4	37.2	15.5	3.9	1.6	--	0.8
4) Individually prescribed program	38.8	23.3	7.0	4.7	--	0.8	2.3	23.3

C. How often do you engage your Biology 200 students in each of the following activities? Write in the appropriate number from the scale below.

1. Hardly ever (e.g., 0, 1 or 2 times during course)
2. Occasionally (e.g., 1 time per cycle)
3. Frequently (e.g., 2 or 3 times per cycle)
4. Very Frequently (almost every biology class period)

	1	2	3	4	No Response
Classroom work					
1) listening to the teacher's lesson, taking notes	1.6	12.4	47.3	38.0	0.8
2) reading from textbook, or from other textual materials	27.1	35.7	26.4	7.0	3.9
3) working on questions given in a textbook; doing worksheets	10.9	48.1	33.3	7.0	0.8
4) discussing assignments and solutions	9.3	38.0	39.5	12.4	0.8
Laboratory Work					
5) designing and preparing their own experiments (pre-lab work)	74.4	15.5	1.6	0.8	7.8
6) preparing experiments from a set of instructions	20.2	48.8	23.3	4.7	3.1
7) conducting experiments	5.4	60.5	25.6	7.0	1.6

VI. C. (Cont'd.)

	1	2	3	4	No Response
8) describing/reporting observations including use of tables and graphs (post-lab work)	25.6%	48.1%	17.1%	5.4%	3.9%
9) analyzing results, drawing conclusions, and preparing research report (post-lab work)	21.7	52.7	16.3	4.7	4.7
10) reviewing/practicing laboratory skills and safety procedures	40.3	41.9	10.1	2.3	5.4
Other					
11) applying information/inferences to new problem situations	33.3	45.0	10.1	4.7	7.0
12) doing library research, or other forms of non-experimental research	48.1	41.1	4.7	1.6	4.7

VII. EVALUATION

A. In evaluating student growth in Biology 200, what emphasis do you place on the following methods of evaluation? Rate each method.

	No Emphasis	Some Emphasis	Great Emphasis	No Response
1) In-class and homework assignments	7.8	67.4	24.0	0.8
2) Lab reports	4.7	65.1	29.5	0.8
3) Teacher-made tests:				
a) multiple-choice, true-false, matching items	9.3	45.0	43.4	2.3
b) non-numeric questions of recall (definitions, etc.)	3.9	65.1	27.9	3.1
c) non-numeric questions of applications, explanations, and derivations	--	48.1	48.8	3.1
d) lab skills tests	24.8	62.0	7.0	6.2
4) Individual projects or research papers	20.9	66.7	8.5	3.9
5) Group projects or research papers	51.2	38.8	3.9	6.2
6) Science fair projects	77.5	14.7	0.8	7.0
7) Standardized multiple-choice or true-false tests	52.7	33.3	11.6	2.3
8) General attitude in class and work habits	29.5	54.3	12.4	3.9
9) Other, specify ____________	--	2.3	1.6	96.1

	Yes	No	No Response
B. Do your Biology 200 students write final exams?	96.9	1.6	1.6
If yes, are there exemptions from Biology 200 final exams available to your students?	40.3	56.6	3.1

C. What procedures do you use to mark students' lab reports *(check one)*?

- 6.2% I do not mark any lab reports
- 8.5 I mark each student's lab report for a sample of lab activities.
- 2.3 I mark a sample of students' lab reports for each lab activity.
- 71.3 I mark each student's lab report for all lab activities.
- 6.2 The students mark lab reports with my guidance.
- 2.3 Other, specify ______
- 3.1 No Response

VIII. STUDENT EXTRACURRICULAR ACTIVITIES IN BIOLOGY

A. What Biology-related activities are available to your students outside of Biology classes? *(check each that applies)*

10.9	1) Environmental club	43.4	5) Science fair
6.2	2) Biology club	10.9	6) Other, specify ______
0.8	3) Dissection club	38.8	7) None
--	4) Bird watching club		

B. What biology-related tours/field trips are available to your Biology students?

1) during regular class (specify)______

2) extra curricular (specify) ______

IX. FUTURE DIRECTIONS

A. How would you change the Biology 200 curriculum outline to prepare students for the 21st century?

______

B. What types of Biology inservices/professional development would you be interested in attending *(check each that applies)*?

- 29.5 1) content background (core topics)
- 33.3 2) content background (optional topics)
- 58.1 3) innovative teaching strategies (e.g., co-operative learning)
- 49.6 4) use of the microcomputer in the biology classroom
- 34.1 5) methods for adapting the curriculum
- 22.5 6) assessment techniques
- 79.8 7) update on the newest developments in biology
- 78.3 8) new lab activities to augment the Biology 200 program
- 57.4 9) technological applications (e.g., recombinant DNA, biotechnology, pharmaceutical)
- 12.4 10) other (specify) ______

SCIENCE ASSESSMENT 1990

TEACHER QUESTIONNAIRE
PHYSICS 300

(ENGLISH AND FRENCH LANGUAGE RESULTS COMBINED)

I. TEACHER BACKGROUND

A. How many (academic or professional) university/college courses have you taken in each of the following disciplines? (Count 6 credits as one course and include both undergraduate and graduate courses, and check each that applies.)

	Number of Courses 0	½ - 1	more than 1	No Response
1) Biological Sciences/Environmental Sciences	28.9%	[illegible]%	32.5%	16.7%
2) Chemistry	5.3	14.9	78.1	1.8
3) Physics	2.6	12.3	85.1	--
4) Earth Sciences/Geology/Astronomy	26.3	19.3	28.9	25.4
5) Anthropology/Archaeology/ Behaviourial Sciences	21.9	24.6	28.9	24.6
6) Computer Sciences	28.1	23.7	22.8	25.4
7) Mathematics	1.8	10.5	86.0	1.8

B. In which major discipline area(s) outside of Physics have you taught in the last 3 years ***(check each that applies)***?

None	Chemistry	Biology	Computer Science	Mathematics	Junior High School Science	Other (specify)
5.3	35.1	9.6	17.5	56.1	35.1	35.1

		Yes	No	No Response
C. Do you teach:	1. the Physics 200 program?	86.6	12.3	0.9
	2. the Physical Sciences 201 or 301 programs	19.3	66.7	14.0

D. How many years have you taught the Physics 300 program?

1	2	3	4	5	6	7 or more
8.8	6.1	6.1	4.4	5.3	3.5	65.8

	Yes	No
E. Have you taken any university/college science-related courses within the last 5 years?	22.8%	77.2%

If "yes", in what program are/were the courses?________________________

F. Have you attended inservice work related to Physics 300? If "yes", specify the topic and source of the inservice work (e.g., half-day inservice on laboratory skills sponsored by the division).

1) Workshop(s) 44.7 YES → Topic ____________________
49.1 NO Source ____________________
6.1 NR

2) Seminar(s) 14.0 YES → Topic ____________________
49.1 NO Source ____________________
36.8 NR

G. To which professional organizations relating to Physics teaching do you belong *(check each that applies)*.

76.3 1) STAM (Science Teachers' Association of Manitoba)
-- 2) Canadian Association of Science Educators
-- 3) Canadian Association of Physicists
3.5 4) American Association of Physics Teachers
1.8 5) National Science Teachers' Association
2.6 6) Other, specify ____________________

II. SCHOOL ORGANIZATION

	Mean	Median
A. Indicate the number of Physics 300 groups/classes you teach that are:		
full-year/non-semestered	1.6	1.0
semestered	1.4	1.0

	Yes	No	Other	No Response
B. Do you have a combined Physics 300-Physical Science 301 classroom?	5.3%	89.5%	0.9%	4.4%

	Mean	Median
C. How many hours of instruction in total do your Physics 300 classes receive (on average)?	Not Reported	115.0
D. How much time do you spend per cycle, for each Physics 300 class, on these?		
1) preparation for laboratory activities	7.7	1.0
2) preparation of classroom lessons	7.5	2.0
3) marking student work (tests, lab reports, etc.)	7.4	.0

		Mean	Median
E.	How many hours of preparation time per cycle does your timetable afford you?	8.0	4.0
F.	What is your average class size for Physics 300?	17.2	18.0

III. SCHOOL FACILITIES

A. In what type of room do you teach your Physics 300 class *(check one)*?

regular classroom	16.7%	
science laboratory	36.8	
combination regular classroom/laboratory	45.6	
other	0.9	(specify) ____

B. For what percentage of class time would you have a lab facility available to your Physics 300 classes *(check one)*?

0%	10-20%	20-30%	30-40%	40-50%	50-60%	60% or more	No Response
0.9	7.9	4.4	0.9	2.6	2.6	79.8	0.9

C. How adequate are the following physical facilities for teaching Biology 200 to your classes. Please rate your facilities on this 4-point scale.

	Very Inadequate	Inadequate	Adequate	More Than Adequate	Not Applicable	No Response
1) tables/counters	4.4	8.8	51.8	33.3	0.9	0.9
2) storage space for materials/equipment	3.5	14.9	46.5	33.3	0.9	0.9
3) amount of work space per student	2.6	15.8	50.0	29.8	0.9	0.9
4) preparation rooms	17.5	14.0	47.4	12.3	7.0	1.8
5) hot and cold water outlets, and sinks	5.3	14.9	54.4	21.9	2.6	0.9
6) electrical outlets	2.6	11.4	49.1	34.2	0.9	1.8
7) audio-visual equipment	3.5	5.3	64.9	22.8	0.9	2.6
8) lighting	2.6	3.5	57.0	35.1	0.9	0.9
9) storage/display space for student projects	18.4	27.2	37.7	10.5	5.3	0.9
10) other, specify___	0.9	0.9	0.9	0.9	0.9	96.5

D. Which of the following safety equipment does your laboratory facility contain? ***(Check each that applies.)***

71.1%	1) eye wash station	70.2%	6) safety goggles, sufficient for entire class
25.4	2) main power switch/GFCI (groundfault circuit interrupt)	21.9	7) cabinet (safety goggles)
86.8	3) master gas shutoff	90.4	8) fire extinguishers (ABC type)
18.4	4) light indicator for gas shutoff	59.6	9) approved first aid kit
74.6	5) fire blanket	2.6	10) other, specify ____

	Yes	No
E. Do you have a lab assistant for your Physics 300 classes?	15.8	84.2

If yes, what type of assistant do you have? ***(Check each that applies.)***

13.2	paid adult assistant
1.8	paid student assistant
--	volunteer adult assistant
0.9	volunteer student assistant

	Yes	No	No Response
F. Is your laboratory equipment adequate?	72.8	25.4	1.8

If not, what lab equipment (or facilities) are you lacking that you think is necessary to teach the Physics 300 curriculum?

____

	Yes	No	No Response
G. Are your laboratory supplies adequate?	76.3	16.7	7.0

If not, identify in what way(s) they are inadequate: ______________________________

IV. CURRICULUM GUIDE

	Yes	No	No Response
A. Are you using the current Physics 300 Manitoba Curriculum Guide?	98.2	0.9	0.9

B. In teaching Physics 300, to what extent do you base your program on the objectives in the Guide? ***(check one)***

Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	No Response
--	3.5	29.8	65.8	0.9

C. How appropriate are the following aspects of the curriculum in terms of the students you teach? Please rate the aspects on this 4-point scale.

	Not Appropriate At All	Not Very Appropriate	Moderately Appropriate	Very Appropriate	Don't Know	No Response
1) objectives	--	2.6%	46.5%	45.6%	2.6%	2.6%
2) content/topics balance	0.9	4.4	52.6	37.7	0.9	3.5
3) suggested activities (lab)	1.8	4.4	66.7	23.7	0.9	2.6
4) recommended textual material	3.5	12.3	50.9	28.9	--	4.4
5) recommended sources of labs	2.6	10.5	60.5	18.4	3.5	4.4

D. Which of these core units do you teach in your Physics 300 program? ***(Check each that applies.)***

Core Units

98.2 1) Waves

100.0 2) Static Electricity

100.0 3) Fields and Forces

100.0 4) Basic Electrical Circuits

98.2 5) Basic Magnetism

93.0 6) Electromagnetic Induction and Alternating Current

E. If some core units were not completed, please identify why.

____

F. Check each option unit you teach; indicate the approximate amount of classroom time you spend on it. **(English Language Results Only)**

		Mean	Median
I.	Sound	7.2	5.0
II.	Light: Geometrical Optics and Optical Instruments	14.1	14.0
III.	Sunburn	2.0	1.0
IV.	Historical Development of the Atomic theory	6.3	5.5
V.	Earthquake Prediction	1.0	1.0
VI.	Energy Futures	6.0	5.5
VII.	Science, Technology, and Society	3.8	3.0
VIII.	Special Relativity	7.4	7.0
IX.	Radiation and some of its Biological Effects	6.6	6.0
	Other, specify (English Language Results Only)	9.8	10.0

G. If you do not teach any of the options, please identify why.

____

V. TEACHING RESOURCES AND MATERIALS

A. What is the principal text you use for teaching Physics 300 ***(check one)***?
(English Language Results Only)

58.8%	1)	J. Williams, et al., Modern physics. Holt Canada.
1.8	2)	C. Spronk & B. Martin, Physic-Al: Activity approach to physical science. J. M. LeBel Enterprises.
11.4	3)	U. Haber-Schaim, et al., PSSC physics. Heath.
13.2	4)	Martindale, et al, Fundamentals of physics: A senior course. Heath
5.3	5)	Do not use a textbook.
5.3	6)	Other, specify ________________
0.9		No Response

B. How satisfied are you with the text(s) you use?

Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied	No Response
7.0	22.8	57.9	7.9	4.4

C. List other texts/textual materials you use to supplement the principal text.

Text/Textual Materials

____

VI. TEACHING ACTIVITIES AND METHODOLOGY

A. What approach do you follow in implementing the Physics 300 program ***(check one)***?

5.3	Individualized approach
52.6	Group-centered approach
41.2	Group-centered and individualized approach
--	Other, specify ________________
0.9	No Response

B. Approximately what percentage of your allotted time for Physics 300 would be used for each of the following activities?

	0-10%	10-20%	20-30%	30-40%	40-50%	50-60%	Over 60%	No Response
1) Teacher lecture	--	3.5%	14.0%	21.9%	23.7%	20.2%	15.8%	0.9%
2) Teacher demonstration	21.1	53.5	15.8	6.1	--	--	--	3.5
3) Student performed laboratory activities	20.2	40.4	29.8	4.4	0.9	0.9	0.9	2.6
4) Individually prescribed program	24.6	11.4	7.9	6.1	1.8	0.9	--	47.4

C. How often do you engage your Physics 300 students in each of the following activities? Write in the appropriate number from the scale below.

1. *Hardly ever (e.g., 0, 1 or 2 times during course)*
2. *Occasionally (e.g., 1 time per cycle)*
3. *Frequently (e.g., 2 or 3 times per cycle)*
4. *Very Frequently (almost every biology class period)*

	1	2	3	4	No Response
Classroom work					
1) listening to the teacher's lesson, taking notes	1.8	6.1	46.5	44.7	0.9
2) reading from textbook, or from other textual materials	31.6	45.6	14.9	4.4	3.5
3) working on questions given in a textbook; doing worksheets	1.8	7.9	50.9	39.5	--
4) discussing assignments and solutions	0.9	14.0	42.1	42.1	0.9
Laboratory Work					
5) designing and preparing their own experiments (pre-lab work)	75.4	18.4	1.8	--	4.4
6) preparing experiments from a set of instructions	21.9	60.5	14.0	0.9	2.6
7) conducting experiments	7.0	73.7	18.4	--	0.9
8) describing/reporting observations including use of tables and graphs (post-lab work)	11.4	67.5	16.7	--	4.4
9) analyzing results, drawing conclusions, and preparing research report (post-lab work)	15.8	62.3	16.7	0.9	4.4
10) reviewing/practicing laboratory skills and safety procedures	50.9	35.1	7.0	--	7.0
Other					
11) applying information/inferences to new problem situations	30.7	33.3	24.6	5.3	6.1
12) doing library research, or other forms of non-experimental research	73.7	15.8	1.8	--	8.8

VII. EVALUATION

A. In evaluating student growth in Physics 300, what emphasis do you place on the following methods of evaluation? Rate each method.

	No Emphasis	Some Emphasis	Great Emphasis	No Response
1) In-class and homework assignments	16.7%	62.3%	20.2%	0.9%
2) Lab reports	5.3	73.7	17.5	3.5
3) Teacher-made tests:				
a) multiple-choice, true-false, matching items	40.4	36.8	14.9	7.9
b) non-numeric questions of recall (definitions, etc.)	15.8	69.3	7.0	7.9
c) non-numeric questions of applications, explanations, and derivations	4.4	65.8	26.3	3.5
d) lab skills tests	39.5	50.0	3.5	7.0
e) single-step numerical calculation items	4.4	63.2	30.7	1.8
f) multiple-step numerical calculation items	0.9	22.8	73.7	2.6
4) Individual projects or research papers	54.4	37.7	4.4	3.5
5) Group projects or research papers	69.3	22.8	1.8	6.1
6) Science fair projects	80.7	8.8	1.8	8.8
7) Standardized multiple-choice or true-false tests	76.3	14.0	3.5	6.1
8) General attitude in class and work habits	34.2	48.2	13.2	4.4
9) Other, specify ________	0.9	0.9	--	98.2

	Yes	No	No Response
B. Do your Physics 300 students write final exams?	98.2	0.9	0.9
If yes, are there exemptions from Physics 300 final exams available to your students?	24.6	70.2	5.3

C. What procedures do you use to mark students' lab reports (*check one*)?

4.4 I do not mark any lab reports.

10.5 I mark each student's lab report for a sample of lab activities.

4.4 I mark a sample of students' lab reports for each lab activity.

73.7 I mark each student's lab report for all lab activities.

2.6 The students mark lab reports with my guidance.

3.5 Other, specify ____________

0.9 No Response

VIII. STUDENT EXTRACURRICULAR ACTIVITIES IN PHYSICS

A. What Physics-related activities are available to your students outside of Physics classes? ***(check each that applies)***

1.8%	1)	Physics club	10.5%	5)	Other, specify ______
14.9	2)	Photography club	45.6	6)	None
5.3	3)	Astronomy club			
29.8	4)	Preparing for physics contests			

B. What Physics-related tours/field trips are available to your Physics students?

1) during regular class (specify)______

2) e) ·ra curricular (specify) ______

IX. FUTURE DIRECTIONS

A. How would you change the Physics 300 curriculum outline to prepare students for the 21st century?

______

B. What types of Physics inservices/professional development would you be interested in attending ***(check each that applies)***?

44.7	1)	content background (core topics)
42.1	2)	content background (optional topics)
43.9	3)	innovative teaching strategies (e.g., co-operative learning)
63.2	4)	use of the microcomputer in the biology classroom
30.7	5)	methods for adapting the curriculum
16.7	6)	assessment techniques
61.4	7)	update on the newest developments in biology
75.4	8)	new lab activities to augment the Physics 300 program
69.3	9)	technological applications (e.g., recombinant DNA, biotechnology, pharmaceutical)
5.3	10)	other (specify)______

MANITOBA SCIENCE ASSESSMENT 1990

Summary Report

Manitoba
Education
and Training

MANITOBA SCIENCE ASSESSMENT 1990

SUMMARY REPORT

A REPORT OF THE

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Winnipeg, Manitoba January, 1993

PREFACE

This *Summary Report* is the third of three reports of the findings of the 1990 Science Assessment. It contains a brief description of the study along with recommendations based on the student results, teacher survey, information shared by teachers and administrators at the regional meetings held in the early stages of the project, and the judgement of the Technical Advisory Committee. Members of the Committee reviewed the data and interpreted them in the light of their considerable knowledge and experience. Teachers and school administrators are encouraged to review the recommendations for applicability to their own programs.

There are two other reports on this assessment. They are the *Preliminary Report* and the *Final Report*. *The Preliminary Report* presents the actual data obtained from the student results and was distributed to all schools in the province as well as to school division offices, teacher and trustee organizations, libraries, and universities. The *Final Report* presents an analysis of student results and teacher surveys together with conclusions and recommendations. This Report was distributed to school division offices, teacher and trustee organizations, libraries, and universities. Copies of the *Final Report*, however, can be obtained from Manitoba Education and Training on request. This *Summary Report* receives the same wide distribution as the *Preliminary Report*.

ACKNOWLEDGEMENTS

This assessment would not have been possible without assistance and cooperation of people too numerous to mention: the students who wrote the tests; teachers who administered the tests; those who assisted us with the pilot testing; and teachers and others who assisted in the review of the objectives. Special mention must be made of a number of groups and individuals:.

- The contractors who gave professional assistance in every phase of the project.
- The Joint Committee on Evaluation which provided guidance throughout the program.
- The Science Technical Advisory Committees which advised on test production and analysis of results.
- The teachers who participated in the teacher surveys.
- The divisions and schools that released their teachers to assist in the program.
- The secretaries of Manitoba Education and Training for their excellent work in typing the manuscripts.

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CHAPTER 1

Background and Procedures

Purpose:

The Science Assessment Program is part of the overall Manitoba assessment program as recommended by the Joint Committee on Evaluation (JCE) and approved by the Minister of Education and Training. The purposes of the assessment are:

1) To provide benchmark indicators about the level of student achievement in the Province of Manitoba.

2) To obtain data on student achievement that will assist in curriculum and program improvement at the provincial and local levels.

3) To assist school divisions in student and system evaluation.

4) To help teachers improve their evaluation skills.

In the Science/Sciences 100, Biology 200 and Physics/Physique 300, new information was obtained with respect to curriculum achievement. In Chemistry 200 and 300, the results of 1990 were compared to those of 1981.

The Science Assessment was intended to provide a broad base of accurate and current information on the performance of students in Manitoba. No special preparation was made to write these tests so the results reflect an "everyday" level of performance as opposed to an optimum level. From a curricular standpoint, this provides a measure of the extent to which the provincial curriculum is being learned.

Components:

The 1990 Science Assessment Program was administered in the Spring of 1990 to students in Science/Sciences 100, Biology 200 and Physics/Physique 300. Students were given the test in their language of instruction (English or French). The Chemistry 200 and 300 Comparison testing was administered only in the English language as was done in 1981. Biologie 200 will be assessed in 1992.

All the tests, except Science/Sciences 100, focused on the Core Topics of their respective curriculum. Science/Sciences 100 tested three compulsory Core Topics, four required options and one additional option. It was not feasible to test the many options in the other programs since this would have resulted in huge test booklets, difficulty in administering the tests, and confusion to students completing the tests.

In every instance, the tests comprised multiple choice items and long answer type questions. The limitations of costs prohibit wider use of supply-type items, particularly those designed to test process skills. However, the current proportion of select-type and supply-type items allows for adequate cross-referencing of students' understanding of concepts.

In addition to the written test, the Science Assessment Program consisted of a Teacher Survey of all of the courses assessed except Chemistry 200 and 300. This is considered a valuable component of the assessment program in that it provides authentic information regarding teacher and student interaction with the prescribed curriculum.

In its earlier deliberations, the Technical Advisory Committee considered including a Performance component in each test. However, the limitations of cost discouraged further action in this direction. The merits of a Performance component in the Assessment Program, especially in the sciences, were certainly endorsed.

Time:

The assessments were conducted towards the end of May and beginning of June, 1990. It was felt that teachers and students of full-year and second-semester programs would have been concluding their programs by that time. The timing of provincial assessments has always come under question. Some teachers, especially those in semestered schools, claim that assessments conducted in late May or early June greet them well short of completing the prescribed curriculum. But, Manitoba Education wishes to avoid conflicts with locally-administered examinations and out-of-school activities.

Sample:

Students identified for the assessment consisted of those in full-year or second-semester programs. For English language programs, random samples of students were identified from class lists provided by public schools in the province. A ten percent sample was selected in Science 100, 20% samples in each of Biology 200 and Physics 300. Due to smaller enrolments in Français and French Immersion programs, all students enrolled in Sciences 100 and Physique 300 were identified for the provincial sample. Biologie 200 was not tested at this time.

In Chemistry 200 and 300 Comparison testing the provincial sample consisted of 28 schools randomly selected for each of Chemistry 200 and 300. This sampling procedure differed from that of 1981 in which approximately 20% of all Chemistry 200 and 300 students in Manitoba's public schools were randomly designated in advance for the provincial sample.

The cluster sampling employed in 1990, as opposed to simple random sampling, proved to be administratively efficient for Manitoba Education and Training in that fewer schools had to be contacted. The overall cost of obtaining a completed assessment was substantially lower for cluster sampling.

Test Development and Administration:

A Technical Advisory Committee (TAC) was established for each science course assessed except for the comparison testing of Chemistry 200 and 300. A contractor was enlisted to assist in the actual development of each test and reporting of results.

Each TAC established the table of specifications and assisted in the review of test items and lay-out of the test. The members of each TAC assisted in the pilot testing at their school and provided direct feedback on timing, language clarity, and other matters of test presentation.

Tests were administered to the students in the provincial sample during the week of May 28 - June 1, 1990. Schools or school divisions that opted to have all their students tested conducted the testing at the same time. Manitoba Education and Training offered a scoring service to these schools or divisions but the actual marking of the tests for the non-provincial sample was done locally. The local decision to test beyond the provincial sample provided teachers, schools and divisions the opportunity to analyze their own results along with the provincial findings. Tests were requested by teachers, schools or school divisions for 93% of schools offering Science 100, 95% offering Biology 200, and 91% offering Physics 300. The entire population of students enrolled in Sciences 100 and Physique 300 formed the provincial sample.

Reporting of Results:

Manitoba Education and Training employs a reporting procedure that includes a Preliminary Report, Final Report and Summary Report. For the Science Assessment Program a separate report was prepared for each of Science 100, Sciences 100 (Immersion), Sciences 100 (Français), Biology 200, and Physics/Physique 300. The Physics/Physique 300 report was translated into French for circulation to the Français and Immersion schools. A combined English language report was prepared for Chemistry 200 and 300 comparison testing.

The *Preliminary Report* was distributed to schools early in the Fall term of the 1990-91 school year. It provided results for each subtest and each item.

The *Final Report* presents an analysis of the results for each course. It contains the major findings plus the conclusions and recommendations made by the TAC and Contract team. A copy was sent to school division offices, teacher and trustee organizations, libraries, and universities.

The *Summary Report* provides a brief description of the findings and recommendations for each course. It is circulated widely to schools so that teachers can utilize the results in planning their programs and instruction. It serves as a source of information to other educational constituencies about the present status of curriculum strengths and weaknesses.

THE TEACHER SURVEY

In addition to student assessment, teachers of each of the Science courses tested were surveyed. No survey was conducted for the Chemistry 200 and 300 Comparison testing. The data provided by experienced and well-informed educators in the field provide Manitoba Education and Training with valuable information for curriculum improvement.

The nine areas in which teachers were asked to provide information were: Teacher Background, School Organization, School Facilities, Manitoba Curriculum Guide, Teaching Resources and Materials, Teaching Activities and Methodology, Evaluation, Student Extra-Curricular Activities, and Future Directions (teaching of the particular Science course).

Questionnaires were sent to a sample of teachers for each of Science 100, Biology 200 and Physics 300. All teachers in Sciences 100 (Français and Immersion) and Physique 300 were surveyed. The information collected from each survey was used by the TAC in formulating meaningful recommendations.

CHAPTER 2

Science 100
Testing and Teacher Survey

Test Results

Table 1 below summarizes the performance of students on the eight subtests.

Table 1

MEAN PERFORMANCE ON SUBTESTS

SUBTEST		NO. OF STUDENTS RESPONDING	TOTAL POSSIBLE MARKS PER SUBTEST	MEAN RAW SCORE	MEAN PERCENT	STANDARD DEVIATION RAW SCORE
1. MEASUREMENT. . .	(MULTIPLE-CHOICE)		10	6.95	69.52	1.70
MEASUREMENT. . .	(WRITTEN-RESPONSE)	568	2	0.69	34.51	0.73
MEASUREMENT AND EXPERIMENTATION	(TOTAL)		12	7.64	63.69	2.04
2. CHARACTERISTICS. . .	(MULTIPLE-CHOICE)		17	10.00	58.84	3.20
CHARACTERISTICS. . .	(WRITTEN-RESPONSE)	568	8	4.39	54.93	2.50
CHARACTERISTICS OF MATTER	(TOTAL)		25	14.40	57.59	4.99
3. SEPARATION. . .	(MULTIPLE-CHOICE)		13	7.52	57.83	2.63
SEPARATION. . .	(WRITTEN-RESPONSE)	568	11	4.55	41.39	2.33
SEPARATION OF SUBSTANCES	(TOTAL)		24	12.07	50.29	4.23
4. FOSSIL FUELS	(MULTIPLE-CHOICE)		6	3.55	59.24	1.48
FOSSIL FUELS	(WRITTEN-RESPONSE)	229	4	2.24	56.11	1.19
FOSSIL FUELS	(TOTAL)		10	5.80	57.99	2.22
5. MOTION. . .	(MULTIPLE-CHOICE)		5	3.22	64.38	1.11
MOTION. . .	(WRITTEN-RESPONSE)	224	5	1.91	38.13	1.39
MOTION AND COLLISIONS	(TOTAL)		10	5.13	51.25	1.96
6. CELLS	(MULTIPLE-CHOICE)		11	7.63	69.32	1.94
CELLS	(WRITTEN-RESPONSE)	350	8	4.84	60.54	2.17
CELLS	(TOTAL)		19	12.47	65.62	3.43
7. NUTRITION	(MULTIPLE-CHOICE)		7	3.92	55.93	1.38
NUTRITION	(WRITTEN-RESPONSE)	153	11	4.42	40.17	2.30
NUTRITION	(TOTAL)		18	8.33	46.30	2.97
8. PARTICLE THEORY	(MULTIPLE-CHOICE)		13	7.84	60.31	2.72
PARTICLE THEORY	(WRITTEN-RESPONSE)	270	8	3.28	40.97	1.97
PARTICLE THEORY	(TOTAL)		21	11.12	52.95	4.15

Findings

The Technical Advisory Committee rated as satisfactory the overall student performance on the core topics. The students demonstrated a very good knowledge of scientific process, particularly with respect to controlling of variables in an experiment. It was noted that students were quite adept at using the formula, "$D = \frac{M}{V}$" and could manipulate the formula in order to solve for either volume or mass if the other variables were given.

It was also evident that students demonstrated strong skills in reading and constructing graphs. Students appeared to have difficulty with problems that required higher level thinking and which could not be solved using a "magical" formula. This weakness was also evident in problems where students had to show an actual understanding of density rather than simply substituting numbers into the formula "$D = \frac{M}{V}$". The TAC also noted that students had some difficulty with the mathematical concepts of ratio and proportion.

The overall student performance on the two options Fossil Fuels and Motion and Collisions was rated as adequate. The Technical Advisory Committee was concerned that in the option Fossil Fuels, only 44% of the students knew the major elements in crude oil, and only 50% of the students actually knew the major elements responsible for acid rain. Considering the present emphasis on the environment, is the relationship between the burning of fossil fuels and its impact on the environment emphasized enough in the teaching of this unit? In the option, Motion and Collisions, the student performance on calculation questions seemed to indicate that very little emphasis was placed on the mathematical aspect.

The overall student performance on the option, Cells, was rated as more than satisfactory. It appeared that this was the most popular option and also the option in which student performance was at the highest level.

The overall student performance on the option, Nutrition, was rated as unsatisfactory. Students demonstrated little knowledge of the calculation of energy in either calories or joules. The TAC was also concerned with the quality of responses and the lack of responses to a question dealing with major medical health hazards which could be caused by crash diets. Considering the present incidence of anorexia and bulimia in our teenage population, one would think that student awareness and knowledge of these health problems would have been greater.

In reviewing the results of the subtest, Particle Theory, the TAC was mindful of the fact that this option was the most difficult in that it contained more abstract thinking and higher level analytical problems. The overall rating of student performance on this subtest was satisfactory. Students seemed to have a fair understanding of the particle nature of matter. Most students could relate mass to number of particles and were well aware of the compressibility of gases and its relationship to the large amount of space between the particles of gas. There was some concern about the students' lack of understanding of diffusion.

General Conclusions

1. The Technical Advisory Committee rated the overall performance on the core topics as satisfactory to good. Perhaps one of the reasons that students performed well on the core topics is that the course is activity oriented.

2. The performance on questions relating to reading, interpreting and constructing graphs was rated as good. Students' understanding of graphing in general was very good. This was viewed as being very positive in that graphic illustrations are used widely in everyday situations.

3. The majority of students could calculate density by using the formula $D = \frac{M}{V}$. The results also indicated that the students could satisfactorily manipulate the formula and solve for the unknown variable if the other two variables were given. The performance on this concept appeared weak when the students had to demonstrate an understanding of density. Density is really a ratio or a fraction, and even though students knew the definition of density as the ratio of mass to volume, the understanding of ratio and proportions was not satisfactory.

4. The relationship of the science concepts or principles in the Individualized Science Instructional Systems (ISIS) modules to every day situations, technology, and the environment was either not stressed by teachers or not well understood by the students. (Nutrition and Fossil Fuels)

5. Most calculation and quantitative questions in the option units were not done well. It was suggested that one of the reasons for the low performance is that the option topics are usually taught at the end of the course. Therefore, the topics may have been covered superficially because of time constraints.

6. In the Committee's view the only negative aspect of the overall results was the fact that the written response component of the test was frequently not attempted. This made it difficult to compare student performance on questions relating to the same topics in both the multiple choice and written response components of the test.

   Perhaps, one reason the students did not attempt written response questions is that they experience difficulty in verbalizing or articulating their answers. Another reason for ignoring written response items was that students did not take the test seriously as it would have had no impact on their final grade.

<u>Teacher Survey</u>

Detailed responses to the teacher survey are to be found in the Final Report. The following are some of the highlights in each of the nine areas in which teachers were asked to provide information:

I. TEACHER BACKGROUND

The majority of Science 100 teachers have university level courses in Chemistry (80.6%), Biology (55.6%), Physics (48.6%), and Mathematics (68.1%) and have taught Science 100 for more than seven years (56%).

II. SCHOOL ORGANIZATION

More than half of the respondents teach in a semester system. On the average, teachers have approximately 110 hours of instructional time for their Science 100 course.

III. SCHOOL FACILITIES

Over 80% of teachers instruct Science 100 in a science laboratory or combination classroom/laboratory setting, and have laboratory facilities available to them for more than 60% of instructional time.

IV. CURRICULUM GUIDE

Approximately 95% of teachers use the curriculum guide and 88% of teachers place moderate to great emphasis on the objectives in the guide. All options listed in the curriculum guide were taught, some more than others.

V. TEACHING RESOURCES AND MATERIALS

The most frequently used textbooks for the compulsory topics in Science 100 were:

. *Physical Science: An Introductory Study* by W. A. Andrews et al; and
. *Introductory /Physical Science* by U. Haber-Schaim et al

The following ISIS textbooks were used extensively in teaching the options:

. Packaging Passengers;
. Let's Eat;
. Cells and Cancer; and
. *Fossil Fuels*

were used extensively in teaching of the options.

VI. TEACHING ACTIVITIES AND METHODOLOGIES

There appears to be a heavy emphasis on student-performed laboratory activities in Science 100. Almost 50% of teachers indicated that student-performed laboratory activities make up 40% to 60% of instructional time.

VII. EVALUATION

Most of the teachers evaluate student performance on teacher-made tests. Fifty-nine point seven percent (59.7%) of teachers indicated that they marked each student's laboratory report for all laboratory activities. Ninety-four point four percent (94.4%) of teachers indicated that their students write final exams.

VIII. STUDENT EXTRA-CURRICULAR ACTIVITIES

Thirty-five point two percent (35.2%) of teachers do not provide any opportunities for students to participate in any science-related activities outside of Science 100 classes. Forty-seven point two percent (47.2%) of respondents stated that their students participated in Science fairs. Some science-related tours/field trips are available to Science 100 students and these are detailed in the Final Report.

IX. FUTURE DIRECTIONS

Teachers have varied views as to the design of the Science 100 course in the future. Several teachers (11%) indicated that the ISIS materials are not rigorous enough for a Science 100 student and should be eliminated from the course. It was suggested that the option, ''Particle Theory'', be added to the list of compulsory topics (18%). Many of the respondents suggested that the compulsory topics be retained but new optional topics be designed to reflect current concerns like sustainable development strategies (14%).

Recommendations

The recommendations that follow are based on the results of the Science 100 assessment and the insights of teachers on the Technical Advisory Committee. These recommendations have implications for specific target groups or their implementation may entail overlapping responsibilities with other groups. The letter(s) at the end of each recommendation indicates the group(s) to which it is principally directed. This legend provides the letter symbol for each target group:

Manitoba Education and Training	**= M**
Teachers	**= T**
School Divisions and Administrators	**= S**
Faculties of Education	**= F**

The Science 100 curriculum consists of five Optional topics. The student results reveal that all the Optional topics are taught but Cells and Cancer and Particle Theory appear to be the two most popular ones (see Table 1 on page 7). Actually, students performed best on Cells and Cancer ^nd it was the opinion of several teachers (22%) that this topic could be covered in Grade 9 (Senior I). Particle Theory provides a greater challenge for students in abstract thinking and higher order thinking skills which, in turn, provide a good foundation for later study in Science. Twenty-two percent (22%) of the teachers surveyed suggest that Particle Theory be added to the list of Core topics. Therefore, it is recommended that:

1. **the present Core topics be retained but add Particle Theory to the list with continued emphasis on laboratory activities and skills. (M, T)**

A fair number of the teachers surveyed (22%) would like to see a more rigorous Science 100 course, a course with more emphasis on Physics and Chemistry. This may require the extension of the compulsory topics and a de-emphasis of Optional topics like Nutrition which can be incorporated into Home Economics or Health studies. It is the favoured opinion (26%) of the teachers surveyed that too much of the present content is a repeat of ideas taken in Junior High even though the student results may not reflect the easiness of the program. The Technical Advisory Committee surmises that the program lacks challenge. As such, it is recommended that:

2. **the materials and resources for Optional topics be reviewed in order to provide a greater challenge to Science 100 students. (M)**

3. **the inclusion of Core and Optional topics in the Science 100 course consider those that reflect present-day concerns like sustainable development, pollution and health-related issues (cancer, AIDS, etc.) (M)**

The student results show low performance for almost all written-response questions. Based on the review of these results and that of the teacher survey which indicates that teachers wish to provide more opportunities for students to do problem solving and write-up their solutions, the Science 100 Technical Advisory Committee recommends that:

4. **teachers provide their students with increased opportunities for recording written solutions and explanations of processes used in problem solving and completing long answer questions on tests. (T)**

5. **Faculties of Education emphasize the importance of language structure in long answer questions on assessment in all science courses when preparing teacher trainees on Student Evaluation. (F)**

Even though few teachers (5 out of 216) made specific comments on the expectations of university courses in Science Education, the Technical Advisory Committee felt that it was important for the Faculty of Education to offer a course specific to the teaching of Science 100. This particular course is a mixture of Chemistry, Physics and Biology and is activity oriented. It is anticipated that the course would not deal merely with science content but with teaching methodologies and approaches as well. Thus, it is recommended that:

6. **the Faculties of Education develop special methodology courses for the teaching of specific high school science courses, for example, Science 100. (F)**

On average, teachers had 24 students in their Science 100 classes and spent an average of 7.5 hours per six-day cycle in preparing laboratory activities and classroom lessons and in marking student laboratory reports, assignments and tests. Larger classes will require more time for these instructional activities, especially with classrooms of varied learning abilities. Therefore, it is recommended that:

7. **school divisions maintain class sizes in Science 100 to a maximum of 25 students in order to administer a basically laboratory-oriented program. (S)**

A substantial number of teachers surveyed indicated that their laboratory facilities may not have the required safety equipment. For example, only 20.4% confirmed that there is a main power switch (CFCI or Grand Fault Circuit Interrupt) in their laboratory; 34.3% claim they have safety goggles; 56.9% have an approved First Aid kit; 30.6% have a deluge shower; and 55.6% have a fume hood. Based on the lack of proper safety measures in some laboratory facilities, it is recommended that:

8. **all laboratory facilities meet the safety requirements of Workplace Hazardous Material Information System (WHMIS), and schools be provided with appropriate support to satisfy the regulations. (S)**

In reviewing the pattern of responses for the written-response questions, the Technical Advisory Committee noted that student performance was generally weak. While the Committee felt the poor results might have been attributed to a lack of importance that was attached to the testing or the basic lack of skills and knowledge on the part of students, the members think it is important to provide a good Science foundation for students continuing with further study in Science. Consequently, they suggest that:

9. **teachers provide or continue to provide activities in which discussion and in-depth written responses are used to promote the application of knowledge. (T)**

10. **teachers continue emphasizing problem solving skills and transfer of laboratory understanding to theory. (T)**

11. **teachers emphasize the use of scientific terminology in all instructional activities. (T)**

12. **teachers be more demanding of detail in laboratory reports and written responses. (T)**

CHAPTER 3

Biology 200
Testing and Teacher Survey

Test Results

Table 2 provides a summary of student performance on nine subtests. Homeostasis is not identified as a distinct subtest for instructional purposes, but it is a major theme that runs throughout the course. As a result, it has been given special attention in the assessment.

Table 2

MEAN PERFORMANCE ON SUBTESTS

	SUBTEST		TOTAL POSSIBLE MARKS PER SUBTEST	MEAN RAW SCORE	MEAN PERCENT	STANDARD DEVIATION RAW SCORE
I.	CELL STRUCTURE AND FUNCTION	(MULTIPLE-CHOICE)	18	9.78	54.32	3.22
	CELL STRUCTURE AND FUNCTION	(WRITTEN-RESPONSE)	5	1.49	29.77	1.18
	CELL STRUCTURE AND FUNCTION	(TOTAL)	23	11.27	48.99	3.82
II.	BIOCHEMISTRY	(MULTIPLE-CHOICE)	20	10.06	50.28	3.62
	BIOCHEMISTRY	(WRITTEN-RESPONSE)	3	0.63	21.03	1.03
	BIOCHEMISTRY	(TOTAL)	23	10.69	46.47	4.22
III.	DIGESTION	(MULTIPLE-TOTAL)	13	6.42	49.41	2.62
IV.	TRANSPORTATION	(MULTIPLE-CHOICE)	17	9.12	53.62	3.53
	TRANSPORTATION	(WRITTEN-RESPONSE)	10	2.85	28.46	2.13
	TRANSPORTATION	(TOTAL)	27	11.96	44.30	4.94
V.	RESPIRATORY SYSTEM	(MULTIPLE-TOTAL)	5	2.30	46.09	1.32
VI.	EXCRETORY SYSTEM	(MULTIPLE-TOTAL)	8	3.88	48.51	1.87
VII.	NERVOUS SYSTEM	(MULTIPLE-CHOICE)	9	3.86	42.90	2.16
	NERVOUS SYSTEM	(WRITTEN-RESPONSE)	9	2.49	27.63	2.29
	NERVOUS SYSTEM	(TOTAL)	18	6.35	35.26	3.92
VIII.	ENDOCRINE SYSTEM	(MULTIPLE-TOTAL)	6	2.73	45.50	1.47
IX.	REPRODUCTION AND DEVELOPMENT	(MULTIPLE-CHOICE)	13	5.44	41.87	2.75
	REPRODUCTION AND DEVELOPMENT	(WRITTEN-RESPONSE)	[illegible]	1.88	31.26	1.71
	REPRODUCTION AND DEVELOPMENT	(TOTAL)	19	7.32	38.52	3.87
	HOMEOSTASIS	(WRITTEN-TOTAL)	4	0.66	16.43	0.96

Number of students writing = 604

Findings

Students did reasonably well on the multiple choice questions but their performance was disappointing on the written response items. The subtests in which students performed best were Cell Structure, Digestion, and Excretion. In Cell Structure, students were able to identify parts of a cell satisfactorily but had difficulty with osmosis and mitosis. The straight recall questions in Digestion were done well but those that required integration of knowledge presented difficulty for students. While students were able to identify the basic structures of the human excretory system fairly well, many did not understand how the nephron functions.

The subtests in which students did not perform well were: Homeostasis, Reproduction and Development, and the Nervous System. Even though homeostasis seems to be a major theme running throughout the entire course, only 26.5% of students were able to define the term. In Reproduction and Development, students' knowledge of basic structures was good but their knowledge of functions and mechanism was unsatisfactory. In the Nervous System, students were able to answer questions on the structure and function of a neuron but had difficulty with labelling the parts in a diagram. They also had problems with questions on the eye, ear and brain.

General Conclusions

Generally, the results of the 1990 Biology 200 curriculum assessment test were somewhat disappointing. Even though the students did reasonably well on the multiple choice questions, their performance on the written response items was unsatisfactory. It was the opinion of the Technical Advisory Committee that this could be attributed to the following:

1. Students may not have taken the test seriously as it did not count towards their final mark.

2. Some students did not have the knowledge to answer the questions; others were unable to organize their thoughts and express them clearly on paper.

3. The items dealing with the last 3 units (nervous system, endocrine system, and reproduction and development) were more poorly done than the first six units. Several teachers (21%) indicated that they did not have enough time to teach these units. In many schools the unit on reproduction and development is deliberately taught in Biology 300 as an introduction to genetics.

4. Many students were able to describe single events that occur in a living organism but had difficulty linking ideas together and relating them to a general process like homeostasis.

5. Students experienced great difficulty in questions which entailed transfer of knowledge, even in the multiple-choice section of the test.

Teacher Survey Results

A detailed analysis of the teacher survey is available in the *Science Assessment 1990 Final Report* (Chapter 4). The highlights are as follows:

I. TEACHER BACKGROUND

Biology 200 teachers are generally well qualified academically. Between 61.2% to 87.6% have taken 5 or more university courses in Biology and Chemistry. The majority of these teachers (65.9%) have taught Biology 200 for more than seven years. Although many of the Biology 200 teachers (75.2%) have not taken any science-related courses within the last five years, 45.7% have attended workshops and another 31% have attended seminars related to the Biology 200 program.

II. SCHOOL ORGANIZATION

The average class size for Biology 200 was 24 students. Teachers indicated that they spend an average of 10 hours per cycle preparing lessons and laboratory activities. Fifteen point five percent (15.5%) of schools have combined Biology 200 and 201 classes.

III. SCHOOL FACILITIES

Most teachers (83%) teach the Biology 200 course in a Science laboratory or a combined classroom/laboratory. The majority of teachers (78.3%) indicated that they have access to a laboratory for 60% or more of their instructional time.

While most teachers (77.5%) indicated that their laboratory equipment is adequate, some expressed dissatisfaction with inadequate ventilation (41.1%), lack of storage space for volatiles and chemicals (36.5%), lack of cold storage facilities (31%), and lack of preparation rooms (26.3%).

IV. CURRICULUM GUIDE

Almost all teachers (98.4%) are using the Manitoba Curriculum Guide. Most teachers endorse the course objectives, content, suggested activities, and recommended textbooks but a few (11%-16%) expressed their dissatisfaction with these aspects of the Guide.

While most of the Core units are being taught, the ones that are most often omitted are: Reproduction and Development, Endocrine System, Nervous System, and Excretory System.

The options taught most frequently are Heart Health and Sexually Transmitted Diseases. The ones taught least frequently are Aging Human Behaviour and Basic Ecology.

V. TEACHING RESOURCES AND MATERIALS

The majority of teachers (79.5%) are satisfied with the primary textbook they are using. The textbooks used most widely are:

Biology. Komondy, E. J., and Essenfeld, B.E. Addison-Wesley, 1984.
Biology of Ourselves. Berry, G. and Gopaul, H. John Wiley and Sons, 1982.

VI. TEACHING ACTIVITIES AND METHODOLOGIES

Teacher lecture is the most common methodology used in Biology 200 classrooms followed by student laboratory activities (once per cycle on average).

VII. EVALUATION

Biology 200 students are evaluated primarily by teacher-made tests. Some emphasis is placed on homework assignments, laboratory reports and individual projects or research papers. Almost all (96.9%) Biology 200 students write final examinations.

VIII. STUDENT EXTRA-CURRICULAR ACTIVITIES

Many teachers take their students on field trips to the Delta Field Station, Fort Whyte Nature Centre, Freshwater Fisheries Laboratory, and so on. But, the main activity available to students outside of Biology classes is the Science Fair.

IX. FUTURE DIRECTIONS

Some suggestions offered by teachers to improve the Biology 200 program are:

1. Place greater emphasis on "hands on" laboratory activities.
2. Emphasize process skills, problem solving, and critical thinking in teaching and learning science.
3. Let the curriculum emphasize major biological themes and concepts as opposed to recall of terminology and facts.
4. Clarify objectives in the curriculum guide.
5. Teachers are to be kept updated on current developments in Biology.

Recommendations

The recommendations that follow are based on the results of the Biology 200 Assessment and the insights of teachers on the Technical Advisory Committee. These recommendations have implications for specific target groups or their implementation may entail overlapping responsibilities with other groups. The letter(s) at the end of each recommendation indicates the group(s) to which it is principally directed. This legend provides the letter symbol for each target group:

Manitoba Education and Training	**= M**
Teachers	**= T**
School Divisions and Administrators	**= S**
Faculties of Education	**= F**

It appears that the Biology 200 course has too much content to be covered in the allotted time. Twenty-one percent (21%) of the teachers surveyed indicated that they are unable to complete the course due to shortage of time. Twenty-one percent (21%) omit Reproduction and Development since they believe it is covered in Biology 300; 15% omit the Endocrine System in preference for other topics such as AIDS; and 12% leave the Nervous System for the end and find that they have run out of time. Therefore, it is recommended that:

1. **the Biology 200 curriculum be restructured so that Reproduction and Development would be integrated into the Biology 300 program. (M)**

From the student results, it has been observed that students encountered difficulty with questions requiring transfer of information, specific details with technical information and the use of diagrams and illustrations. Therefore, it is recommended that:

2. **teachers examine the approaches used in teaching the Biology 200 course with greater focus on problem solving and critical thinking. (M, T)**

The Teacher Survey reveals that over 90% of teachers engage their students in laboratory activities less than 40% of their instructional time. Insufficient preparation time has been cited as a reason for de-emphasizing laboratory activities. A large group of teachers (78.3%) would like a list of new and meaningful laboratory activities which would interest and challenge students. Perhaps, to provide concrete experiences for students which would enable better transfer of knowledge, it is recommended that:

3. **a laboratory supplement that contains meaningful activities for students be provided for classroom teachers. (M, T)**

According to the Teacher Survey, 43.4% of teachers indicated that they have not attended a Biology workshop, and 45% have not attended a Biology seminar within the last five years. Also, when asked about preferred workshops, 29.5% want content background in the Core topics; 33.3% want content background in the Optional topics; 58.1% want innovative teaching strategies; 34.1% want methods for adapting the curriculum; 79.8% wish to have update on the newest development in Biology; 78.3% need new laboratory activities to augment the Biology 200 program; 49.6% need to learn how to use the microcomputer in the Biology classroom; and 57.4% need update on technological applications (e.g., recombinant DNA, biotechnology, pharmaceutical). Based on these obvious needs expressed by teachers, it is recommended that:

4. **a series of workshops which would benefit all Biology teachers throughout the province be offered. (M,S,F) The following topics have been suggested:**

   - **update on the newest developments in biology**
   - **new laboratory activities to augment the Biology 200 program**
   - **innovative teaching strategies**
   - **technological applications**
   - **use of microcomputers in the biology classroom.**

In view of the fact that 22.5% of the teachers surveyed would like inservicing on assessment techniques and roughly 45% of these teachers have not attended Biology-related workshops lately, it may be necessary to ensure that assessment techniques are covered in other training sessions. Most teachers (97%) indicated that their students write final examinations. Therefore, it is recommended that:

5. **the Faculties of Education ensure that their teachers are familiar with a variety of test development techniques. (F)**

6. **school divisions and Manitoba Education and Training provide inservice opportunities for teachers to refresh their student assessment and evaluation skills. (M, S)**

Given the fact that a large number of students did not attempt the written-response questions and that performance was weak for those who did complete them, the Biology 200 TAC felt that students need to be given specific training in writing short and long answers on an ongoing basis. Undoubtedly, this course requires a fair amount of reading and writing. Therefore, it is recommended that:

7. **school counsellors make students aware of the reading and writing skills required for Biology 200. (T)**

8. **teachers provide students with regular practice and feedback on written-response exercises. (T)**

9. **teachers provide students with opportunities to answer higher-level application and problem-solving questions on tests. (T)**

The teachers surveyed indicated that they spend on average 10 hours per six-day cycle in preparing Biology lessons and laboratory activities and the marking of laboratory reports. But, their time-table provides only 4.5 hours preparation time per cycle. Seventy-one point three percent (71.3%) of the teachers say that they mark all laboratory reports for every student. However, over 90% of these teachers indicated that their students are engaged in laboratory activities less than 40% of their instructional time. The de-emphasis on laboratory activities could be a result of insufficient preparation time. Therefore, it is recommended that:

10. **laboratory assistants be made available to assist teachers in providing students with high quality laboratory programs. (S)**

Based on the overall results (student and Teacher Survey) and the insights of the TAC members, the Committee suggests that teachers:

11. **place greater emphasis on the concept of homeostasis as it applies to the various organ systems of the human body.**

12. **provide students with practice in linking ideas together and relating them to a general process like homeostasis.**

13. **keep up-to-date by enrolling in workshops, seminars, and university courses.**

CHAPTER 4

Physics 300/Physique 300
Testing and Teacher Survey

Test Results

The test consisted of only the core topics. It was the opinion of the Technical Advisory Committee that testing of the Option units should be waived due to the flexibility allowed to teachers in selection among the nine option units. The test consisted of both multiple choice questions and long answer type questions.

Table 3 below provides a summary of mean performance of students by subtest.

Table 3

MEAN PERFORMANCE ON SUBTESTS

	SUBTEST		TOTAL POSSIBLE MARKS PER SUBTEST	MEAN RAW SCORE	MEAN PERCENT	STANDARD DEVIATION RAW SCORE
1.	WAVES	(MULTIPLE-CHOICE)	10	6.60	65.97	2.17
	WAVES	(WRITTEN-RESPONSE)	14	6.10	43.55	3.86
	WAVES	(TOTAL)	24	12.69	52.89	5.20
2.	STATIC ELECTRICITY	(MULTIPLE-CHOICE)	6	4.25	70.88	1.40
	STATIC ELECTRICITY	(WRITTEN-RESPONSE)	4	0.63	15.81	1.22
	STATIC ELECTRICITY	(TOTAL)	10	4.88	48.85	2.05
3.	FIELDS AND FORCES	(MULTIPLE CHOICE)	8	3.74	46.76	1.92
	FIELDS AND FORCES	(WRITTEN-RESPONSE)	3	1.45	48.37	1.08
	FIELDS AND FORCES	(TOTAL)	11	5.19	47.20	2.52
4.	BASIC ELECTRICAL CIRCUITS	(MULTIPLE-CHOICE)	12	6.58	54.81	2.66
	BASIC ELECTRICAL CIRCUITS	(WRITTEN-RESPONSE)	8	4.28	53.54	2.16
	BASIC ELECTRICAL CIRCUITS	(TOTAL)	20	10.86	54.30	4.28
5.	BASIC MAGNETISM	(MULTIPLE-CHOICE)	5	2.52	50.47	1.35
	BASIC MAGNETISM	(WRITTEN-RESPONSE)	10	4.02	40.20	3.36
	BASIC MAGNETISM	(TOTAL)	15	6.54	43.63	4.06
6.	ELECTROMAGNETIC	(MULTIPLE-CHOICE)	4	1.51	37.70	1.06
	ELECTROMAGNETIC	(WRITTEN-RESPONSE)	5	2.05	41.00	1.50
	ELECTROMAGNETIC INDUCTION	(TOTAL)	9	3.56	39.53	2.08

Number of students writing = 448

Findings

Unit 1, Waves: The majority of the questions were answered well, albeit some students interchanged the wavelength and the amplitude. The lower performance on the written response questions was mainly due to the inability to draw the diffraction pattern of variable wavelengths around slits of different width. The question on nodal lines was omitted by many students.

Unit 2, Static Electricity: this unit was done well, except for the four-step question on double-charging by induction.

Unit 3, Fields and Forces: Both parts of this unit were done equally well. The only deficiency was the inability of many students to find the direction of a magnetic field and the solution of complex problems which involve inverse square law.

Unit 4, Basic Electrical Circuits: The basic understanding of simple circuits was good. The mixed circuits were solved by the majority of the students. The questions on the electrical potential and current in the individual branches of a complex circuit were answered inadequately.

Unit 5, Basic Magnetism: The students understood the concept of the magnetic field around a magnet and around a current-carrying conductor.

Unit 6, Electromagnetic Induction and Alternating Current: The questions on this subtest were answered poorly, especially the questions about the induction in transformers.

General Conclusions

a) Students were able to do straight-forward applications of formulae but had difficulty where transfer of knowledge and interpretations were required.

b) All multiple choice questions were answered by the students, but the written-response items were not attempted in many instances. However, there were satisfactory responses by those who completed the written-response questions. Actually, the mean score for the multiple choice items and written-response items was almost the same in the Electrical Circuits subtest. Also, in the Fields and Forces and Electromagnetic subtests the mean scores were higher for the written-response items than multiple-choice items.

Teacher Survey Results

A detailed analysis of the teacher survey is available in the Physics/Physique 300 Assessment Final Report. This is a summary of the highlights in the nine areas in which teachers were asked to provide information.

I. TEACHER BACKGROUND

A large majority of the teachers (84.5%) took two or more Physics courses at the university level. Other courses taken were: mathematics, earth science, and chemistry. Forty-three percent (43%) of the teachers indicated that they have attended workshops offered by the Department of Education, SAG and their school divisions within the last five years.

Two-thirds of the teachers taught Physics for more than seven years.

A majority of the teachers (77%) belong to the Science Teachers' Association of Manitoba (STAM).

II. SCHOOL ORGANIZATION

Half of the schools were on a semester system and the other half on a full-year system. On the average, teachers were given 3.75 hours of preparation time per cycle.

III. SCHOOL FACILITIES

A majority of the teachers were satisfied with their instructional facilities, laboratories and the safety of equipment.

Many laboratories had outdated equipment which was in the need of repair. There seemed to be a deficiency in electrical circuits and magnetism apparatus. Many laboratories did not have computers which several teachers would like to have available to them for instruction (13%).

IV. CURRICULUM GUIDE

All teachers use the Curriculum Guide as the basis for their course. All Option Topics were taught but the numbers of students were small in any given option. Some teachers (18%) did not teach any Option Topics due to the lack of time.

V. TEACHING RESOURCES AND MATERIALS

The textbooks used by the majority of the teachers included:

. *Modern Physics* by Williams, J. et al, Holt, Canada or;
. *The Fundamentals of Physics: A senior Course* by Martindale et al, Heath, Canada.

PSSC Physics by Haber-Schaim, R. et al, Heath, Canada was used by 13% of the teachers. The majority of the teachers (75%) were satisfied with the texts they used.

VI. TEACHING ACTIVITIES AND METHODOLOGIES

All teachers include in their teaching methods to different degrees: lecture, laboratory demonstrations, laboratory performance, individualized instructions, problem solving strategies.

VII. EVALUATION

Most of the teachers (83%) evaluate students' performance on: teacher-made tests which include multi-step numerical problems and laboratory reports.

Almost all students write final exams and 75% of teachers mark each student's laboratory report.

VIII. STUDENT EXTRA-CURRICULAR ACTIVITIES

Teachers provide some time for the students to work on science projects during the class periods. Extra-curricular activities included visits to Whiteshell Nuclear Research Station, Planetarium, and University of Manitoba.

IX. FUTURE DIRECTIONS

Some suggestions offered by teachers to improve the Physics 300 program are:

1) ongoing review of recommended textbooks;
2) provision of laboratory guides complete with instructions for teachers and students;
3) incorporation of computers in Physics instruction;
4) inclusion of Electronics in the core topics; and
5) generation of a test item bank which contains questions and answers.

Recommendations

The recommendations that follow are based on the results of the Physics/Physique 300 assessment and the insights of teachers on the Technical Advisory Committee. These recommendations have implications for specific target groups or their implementation may entail overlapping responsibilities with other groups. The letter(s) at the end of each recommendation indicates the group(s) to which each is principally directed. This legend provides the letter symbol for each target group:

Manitoba Education and Training	**= M**
Teachers	**= T**
School Divisions and Administrators	**= S**
Faculties of Education	**= F**

Based on the feedback received on the Teacher Survey, 28% of teachers would like some change in the Physics/Physique 300 curriculum. Generally, teachers want a course with embellished Core topics rather than Option topics. They would like a more practical course that is challenging to a student who is contemplating further study in Science. The Technical Advisory Committee feels that some topics fit better in Physics/Physique 200 than Physics/Physique 300 and vice versa. Thus, it is recommended that:

1. **the units taught in Physics/Physique 200 and 300 be restructured, particularly, shifting Waves from the 300 program to the 200 program, and placing Energy in the 300 program. It appears that the Physics/Physique 200 course has a heavy emphasis on mathematics and Waves fits well. Energy can be used as a review of the Physics/Physique 200 course and blends well with other topics in Physics/Physique 300. (M)**

2. **the curriculum guide be reviewed in an effort to provide greater clarification of content (e.g., unit on Waves) and consider the possibility of placing greater emphasis on "Electronics" in Physics/Physique 300. (M)**

More than ten percent (10%) of the teachers surveyed wish to have better material resources for teaching Physics/Physique 300. Some would like to have textbooks that have more extensive coverage of the various Core and Optional topics. Others wish to have a textbook that is more closely tied to the prescribed curriculum. Thus, it is recommended that:

3. **the recommended textbooks of Physics/Physique 300, along with other available texts, be reviewed to determine the one(s) that cover all the Core topics and some or all of the Options. (M)**

When asked about preferences for inservice or professional development, the results reveal that: 45% of Physics/Physique 300 teachers would like inservicing in content background for the Core topics; 43% in the content background for the Optional topics; 45% would like inservicing on innovative teaching strategies; 30% on methods for adapting the curriculum; 61% on the update on the newest developments in Physics; 62% on the use of microcomputers in the Physics classroom; 67% on technological applications (e.g., super conductivity, nuclear advances); and 76% on new lab activities to augment the Physics/Physique 300 program. Based on this variety of professional development needs, it is recommended that:

4. **professional development opportunities for teachers to upgrade their skills and knowledge and refresh their methodologies for teaching high school Physics courses be provided. (M,S,F)**

5. **opportunities for Physics/Physique 300 teachers to share with colleagues ideas and concerns and ways of overcoming these be provided. (S)**

Almost 45% of the teachers surveyed indicated that their students are not involved in Physics-related co-curricular activities. Yet, at least 8% would like to have a more practical course. Therefore, it is recommended that:

6. **teachers endeavour to have students involved in Physics-related co-curriculur activities, thereby enhancing the practical aspect of the course(s). (T)**

7. **teachers provide students with a Physics/Physique 300 program that has sufficient blend with theory and its application. Let learning be related to everyday life as much as possible. (T)**

CHAPTER 5

Chemistry 200/300 Comparison Testing 1981-1990

Background

The Chemistry 200/300 comparison testing was conducted in June, 1990. The objective was to compare the knowledge level of students in Chemistry 200 and Chemistry 300 from 1981 to 1990. In 1981 the provincial sample was twenty percent (20%) of all students enrolled in Manitoba Public Schools. In 1990 the provincial sample consisted of clusters of 28 schools randomly selected for both Chemistry 200 and 300.

In order to reflect the shift in curriculum from 1981 to 1990 as evidenced by the 1984 Curriculum Guide which is still in use, a number of test items were deleted from the 1981 test such that the 1990 test was designed to be written in one hour rather than two hours as in 1981. There was no change in the presentation of the items that were retained from the 1981 instrument. The 1990 instrument maintained a balance of select-type items and written response items. Both the Chemistry 200 and Chemistry 300 tests covered only the core topics.

Summary of Findings

Chemistry 200

The units contained in the Chemistry 200 test were: Introduction to Periodic Table and Elements; Concepts of Matter; Organic Chemistry; Gases; Solutions; and Safety. Table 4.1 shows the mean performance of students for each subtest in 1981 and 1990.

The mean performance of students was consistent in the two years for all the subtests except for two in which the 1990 mean performance was significantly lower than that of 1981. These two areas were: Concepts of Matter and Solutions. It was found that the written response questions were filled by less than half of the students in both 1981 and 1990.

Table 4.1

Analysis Summary for Chemistry 200 (1981 vs 1990)

Variable (Subtest)		Maximum Score Possible	Mean Score		Confidence Interval		Significance 1981 vs 1990
			1981	1990	1981	1990	
Periodic Table	(MC)	17	9.624	9.417	(9.291,9.957)	(8.743,10.082)	NS
Concepts of Matter	(MC)	14	8.347	7.152	(8.059,8.635)	(6.450,7.854)	*
Organic Chemistry	(MC)	10		4.236		(3.511,4.961)	
Gases	(MC)	11	5.616	5.347	(5.375,5.857)	(4.802,5.892)	NS
Solutions	(MC)	11	5.938	5.077	(5.706,6.170)	(4.506,5.648)	*
Safety		7	4.614	4.337	(4.470,4.758)	(3.953,4.721)	NS
Gases	(WR)	4	1.211	1.057	(1.076,1.346)	(0.765,1.349)	NS
Solutions	(WR)	1	0.314	0.101	(0.266,0.362)	(0.046,0.156)	*
MC TOTAL (except Organic Chemistry)		60	34.140	31.330	(33.258,35.022)	(28.808,33.853)	NS
WR TOTAL		5	1.525	1.159	(1.369,1.681)	(0.831,1.487)	NS
CHEM TOTAL		65	35.665	32.489	(34.702,36.628)	(29.739,35.239)	NS

MC = Multiple Choice
WR = Written Responses
*** = Significant difference from 1981 to 1990**
NS = Not Significant

<u>Chemistry 300</u>

The units contained in the Chemistry 300 test were: Electronic Structure, Bonding, Periodic Table Elements; Reaction Rate and Chemical Equilibrium; Ionic Equilibria--Acids and Gases; Solubility; Oxidation-Reduction; and Safety. Table 5.1 shows the mean performance of students for each subtest in 1981 and 1990.

Out of the five subtests there were only two in which there was a significant decrease in performance from 1981 to 1990. These were Electronic Structure, Bonding, Periodic Table Elements and Reaction Rate and Chemical Equilibrium. The written response items were filled by less than half of the students in 1981 and 1990. However, fewer students answered the written response items in 1990 than in 1981. For example, 53.2% of students attempted the long answer questions in Oxidation-Reduction in 1981 as opposed to 12.9% in 1990 and 43.5% attempted the long answer questions in Solubility in 1981 as opposed to 28.9% in 1990.

Table 5.1

Analysis Summary for Chemistry 300 (1981 vs 1990)

Variable (Subtest)	Maximum Score Possible	Mean Score		Confidence Interval		Significance 1981 vs 1990
		1981	1990	1981	1990	
Electronic Structure, Bonding, Periodic Table (MC)	12	6.420	5.857	(6.114,6.726)	(5.143,6.572)	NS
Reaction Rate and Chemical Equilibrium (MC)	11	6.387	5.407	(6.103,6.671)	(4.818,5.997)	*
Ionic Equilibria - Acids & Bases (MC)	12	6.585	6.412	(6.281,6.889)	(5.722,7.102)	NS
Solubility (MC)	6	2.774	2.522	(2.609,2.939)	(2.175,2.869)	NS
Oxidation-Reduction (MC)	15	5.826	5.263	(5.491,6.161)	(4.636,5.890)	NS
Safety	7	4.892	4.855	(4.729,5.055)	(4.514,5.197)	NS
Electronic Structure, Bonding, Periodic Table (WR)	7	2.844	2.086	(2.643,3.045)	(1.623,2.549)	*
Reaction Rate and Chemical Equilibrium (WR)	5	1.554	1.049	(1.781,1.727)	(0.643,1.455)	NS
Solubility (WR)	3	0.903	0.523	(0.770,1.036)	(0.237,0.809)	NS
Oxidation Reduction (WR)	5	1.215	0.835	(1.047,1.383)	(0.464,1.206)	NS
MC TOTAL	63	32.884	30.317	(31.792,33.976)	(27.543,33.090)	
WR TOTAL	20	6.516	4.492	(6.059,6.975)	(3.197,5.788)	*
CHEM TOTAL	83	39.450	34.809	(37.969,40.831)	(30.812,38.806)	NS

MC = Multiple Choice
WR = Written Responses
* = Significant difference from 1981 to 1990
NS = Not Significant

Recommendations

From examining the 1990 results it appears that student performance had not improved since 1981 and even showed greater weakness in areas involving calculations. Therefore, it is recommended that:

1. **Manitoba Education and Training review the recommendations of the Chemistry Assessment 1981 Final Report and implement strategies that would enable teachers to deliver a curriculum resulting in higher student performance. (M,S)**

2. **Manitoba Education and Training review the recommendations of the Chemistry Assessment 1981 Final Report and examine the suggested restructuring of the Chemistry 200 and 300 programs that may allow for better integration of content.**